POWER PLANT ENGINEERING

Established Over 32 Years

VOL. XXXII CHICAGO, APRIL 1, 1928 No. 7

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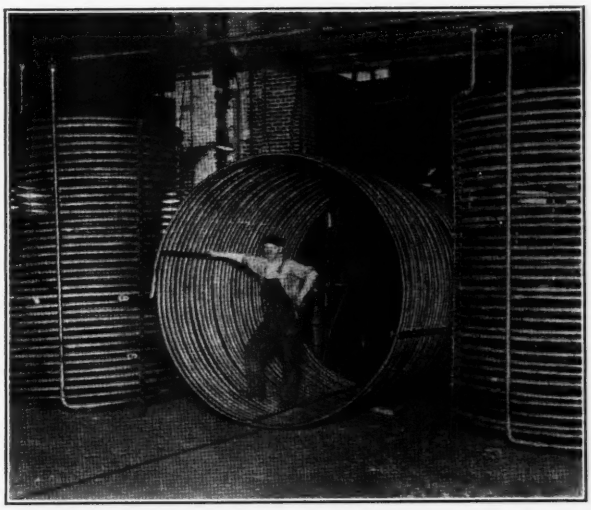
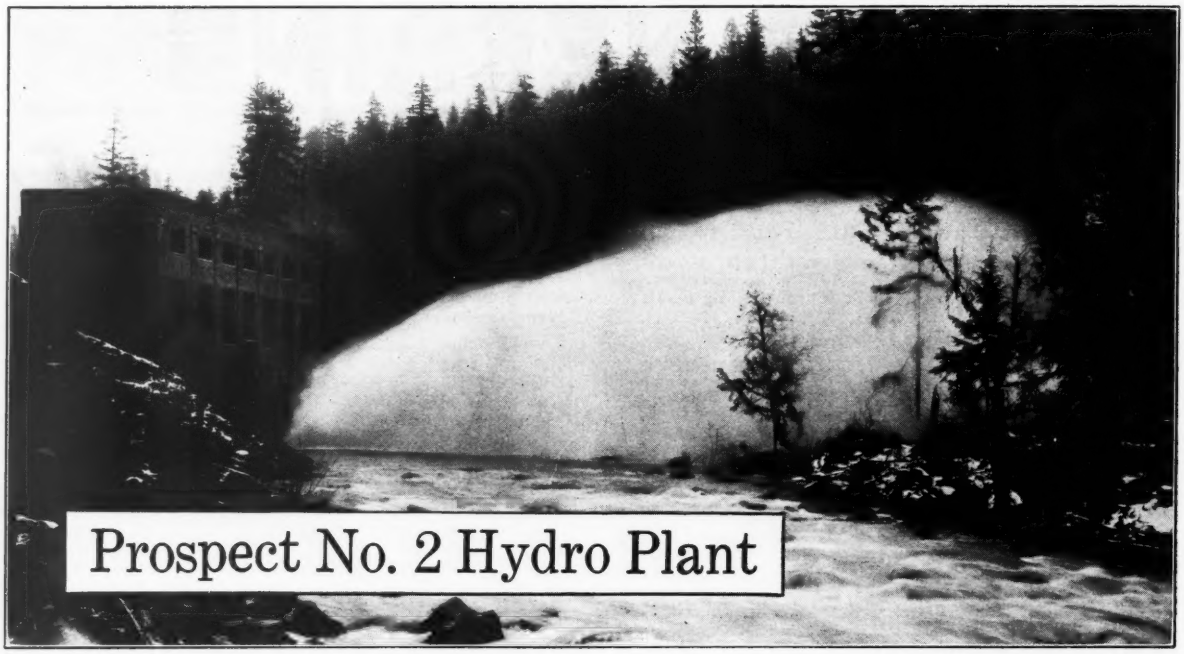


Aha! Stills!

DON'T ALLOW yourself to be illuded any further. These are not coils for stills, but rather for the purpose of making ice water, though it is hard to believe that the demands for drinking water would be so great at any one place and time as to require such large coils. The refrigerating industry, however, has always been associated with the beverage business, having been born, in this country, in a brewery, so it would hardly do to question the judgment of those so familiar with the liquid requirements of a community that even the nomenclature in the two fields have many words in common though the meanings may be different. Note, for example: stills, joints, leaks, piped up, on ice, foaming, skimming—surely early associations have left their traces.

Be that as it may, the refrigerating industry has made considerable progress in recent years; among the noteworthy practices now growing in favor is the welding of joints so that coils like those shown above can be made up without a fitting.

Elsewhere in this issue, the methods used to eliminate joints and to avoid leaks are discussed under the title Piping for Refrigeration. Recent developments and tendencies in refrigerating piping and fittings are also enumerated. The effect of standardization on the industry and other matters that should be of interest to those who toil in order that we may be cool are discussed.



Prospect No. 2 Hydro Plant

NEW HIGH HEAD HYDRO PLANT OF THE CALIFORNIA OREGON POWER COMPANY HAS PRESENT CAPACITY OF 40,000 KV.A. IN TWO UNITS

IN JANUARY, 1928, Prospect No. 2 hydro plant of The California Oregon Power Co. with two 23,400-hp. units operating under a head of 590 ft. was put into regular service. This company, a subsidiary of the Standard Gas & Electric Co., serves light and power to 55 communities in Northern California and Southern Oregon, covering a territory approximately 90 by 200 mi. The plant was designed and constructed by, and will be operated under the supervision of, the Byllesby Engineering & Management Corp. In addition to the electric service supplied direct to customers, large amounts of energy are wholesaled to other companies, connection with the Mountain States Power Co. being at Springfield, Oregon to the north and with the Pacific Gas & Electric Co., at Delta and Kennett, Calif., to the south. The load factor of the entire system is in the neighborhood of 70 per cent.

This development, shown in Fig. 1, on the Rogue River, will operate in parallel with eleven other hydro-electric plants aggregating 91,970 hp., the most important being Copco No. 1 and Copco No. 2, representing a combined capacity of 73,500 hp. A map of the entire system is shown in Fig. 3 with the various plants of the system connected by a high voltage transmission system totalling 764 mi. The low-voltage distributing system totals 923 mi.

Rivers in this territory are characterized by a remarkable uniformity of flow throughout the year, a condition that makes possible a relatively inexpensive development, as comparatively small expenditures for artificial storage are necessary. It is estimated that at this plant the first 16,000-kw. primary power (100 per cent load factor) can be carried by the regular run of the stream without storage.

Briefly, the development consists of a diversion dam,

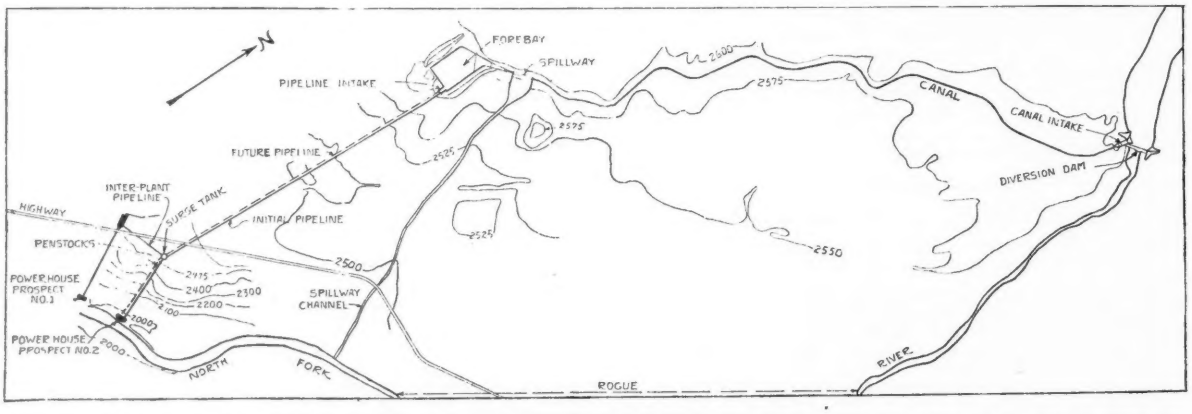


FIG. 1. MAP OF THE PROSPECT NO. 2 DEVELOPMENT, SHOWING THE RELATION OF THE DAM AND FOREBAY TO THE OLD AND NEW PLANTS

a 7000-ft. canal terminating at the forebay, 3100 ft. of 87-in. wood stave pipe, a surge tank and 900 ft. of riveted steel penstock. The ultimate capacity of the station is three 23,400-hp. wheels, each unit to be complete from the forebay to the power house with its own woodstave pipe, penstock, direct connected exciter, oil pressure governor and bypass. Two Pelton reaction turbines, each driving a 20,000-kv.a., 80 per cent power factor, 6600-v., 60-cycle, 3-phase General Electric generator at 514 r.p.m. under an operating head of 590 ft. are now installed. Efficiency guarantees of the turbine and generators are given in Table I. Each generator is connected directly to a bank of three single-phase transformers, both generators and transformers being protected by differential relays.

From the surge tank a temporary 36-in. bypass has been provided to furnish water to Prospect No. 1 plant. This plant, built about 1911, contains one horizontal single runner reaction turbine, rated at 7000 hp. at 514 r.p.m. under a head of 525 ft. It drives a 3750-kw., 2300-v., 60-cycle, 3-phase generator. Ultimately, upon the installation of Unit No. 3 at Prospect No. 2, this plant will be abandoned. The old forebay was originally supplied with water by a flume extending up to the present diversion dam and cutting the present woodstave pipe line between the new forebay and the Crater Lake highway.

Elevations above normal tail water are given in Table II. Axial lengths of the penstock and pipe line sections are 900 and 3100 ft. respectively and the canal is 7000 ft. long. The power house is in a canyon, with the operators houses, surge tank, switchyard and sub-

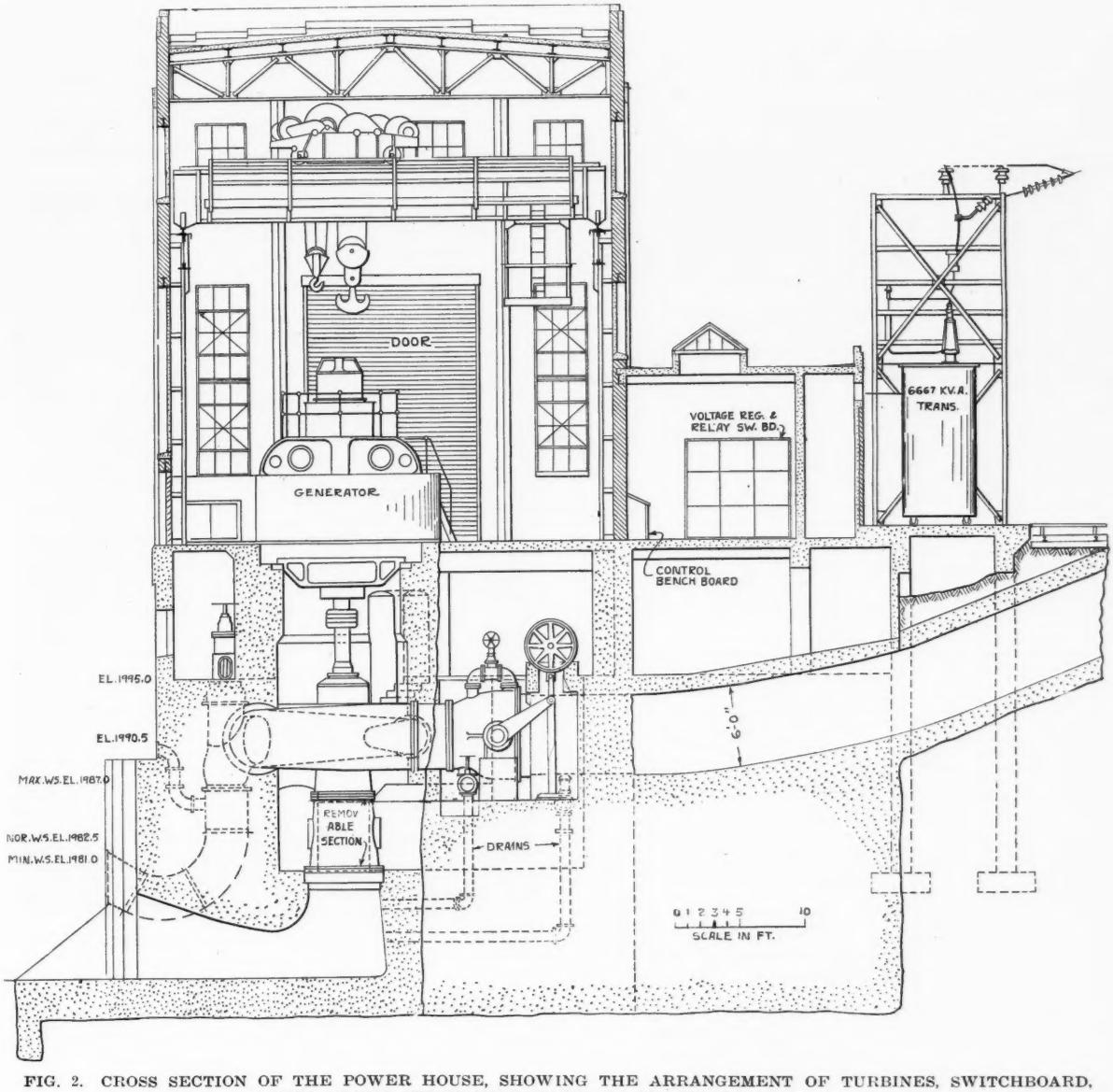


FIG. 2. CROSS SECTION OF THE POWER HOUSE, SHOWING THE ARRANGEMENT OF TURBINES, SWITCHBOARD, CONTROL DESK AND TRANSFORMERS OF PROSPECT NO. 2 PLANT

TABLE I. EFFICIENCY GUARANTEES OF THE TURBINES AND GENERATORS

Load	Efficiency
12,000 hp.	84 per cent
15,000 hp.	87 per cent
18,000 hp.	89.5 per cent
21,000 hp.	90.0 per cent
23,400 hp.	85.5 per cent
Generator eff. (full load)	96.8 per cent

station located on the rim above about 500 ft. higher. The forebay is approximately 115 ft. above the base of the surge tank.

TABLE II. ELEVATIONS ABOVE NORMAL TAIL WATER

Normal tail water	0.0 ft.
Center line of scroll case	8.0
Junction of woodstave pipe and penstock (surge tank)	492
Forebay (normal level)	607
Dam (head water)	614.5

The power house itself, Fig. 4, and the headpiece, is faced with run of kiln brick, ranging in color from medium buff to dark brown. They are set without regard to color, giving a mottled effect blending in well with the landscape. As shown in the plan, Fig. 5, the building, foundation and draft tube as far as the scroll case are completed ready for the installation of the third unit.

General arrangements of the station can be seen from Figs. 2 and 5. Each unit has a 72-in. motor operated butterfly valve and a relief bypass with a capacity of 75 per cent of the full load flow to the turbine. This bypass is under the control of the oil pressure governor; at least it is opened by the governor and closed slowly by a dashpot arrangement.

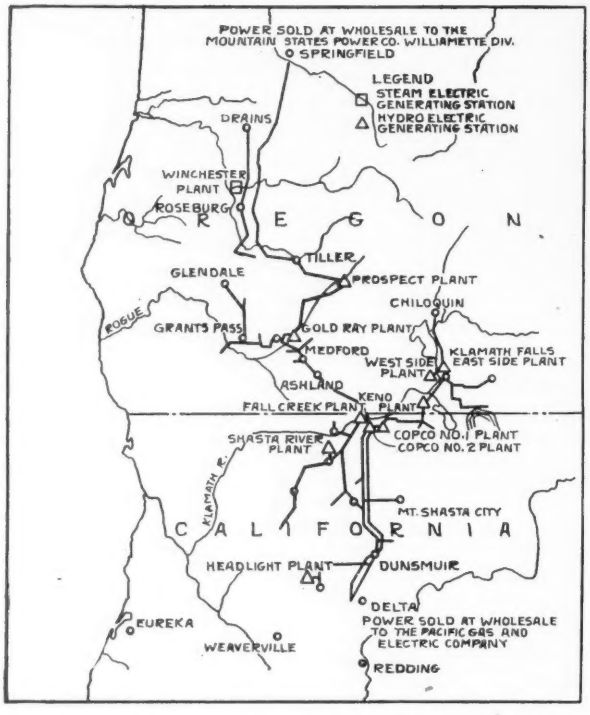


FIG. 3. TERRITORY SERVED BY THE CALIFORNIA OREGON POWER CO. COVERS AN AREA OF ABOUT 90 BY 200 MI.

Station Has Some Unusual Features

Several features of the station are of especial interest. The draft tubes are made with a removable cast-iron section, shown in Fig. 2, immediately below the scroll case. When it is necessary to remove the wheel for inspection or repair, this section can be removed and the wheel or runner dropped down through the bottom of the scroll case, without disturbing the generator. After removal from the scroll case, the runner can, of course, be lifted up to the main floor by the power house crane through the hatch, indicated in Fig. 5.

If the generator rotor is to be removed, provision has been made to make it convenient to work on and, at the same time, not subject the floor to excessive loads. The small cover, marked A in Fig. 5, covers a casting with a hole of the proper diameter to pass the shaft. Below this is a concrete pillar built up from the basement floor sufficiently high so that when the generator rotor is removed from the stator and the shaft lowered through the hole in the casting until it rests on the pillar, the bottom of the rotor will come about 3 ft. above the main floor.

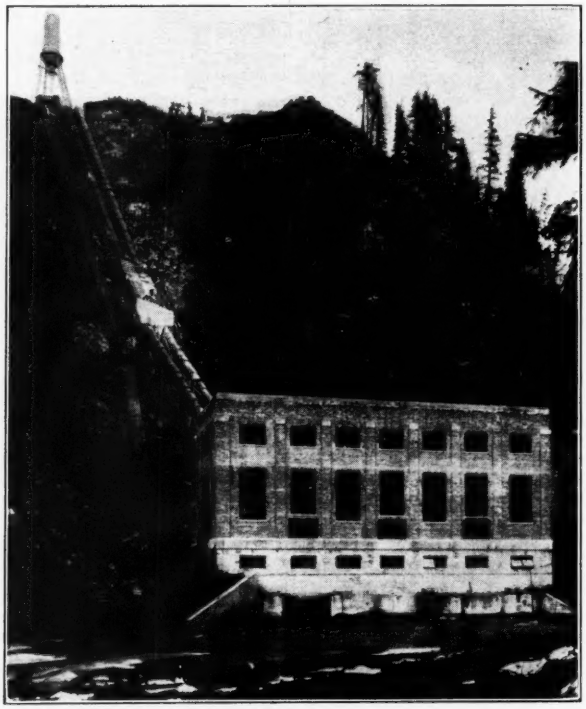


FIG. 4. THE POWER HOUSE IS LOCATED IN A CANYON ABOUT 500 FT. BELOW THE SURGE TANK

The third item is in connection with the penstock expansion joints, used between anchors. In order to reduce friction between the concrete cradles and the steel penstock, $\frac{1}{16}$-in. service packing was cemented to both the penstock and the cradles with graphite used between them for lubrication. Although the scheme has

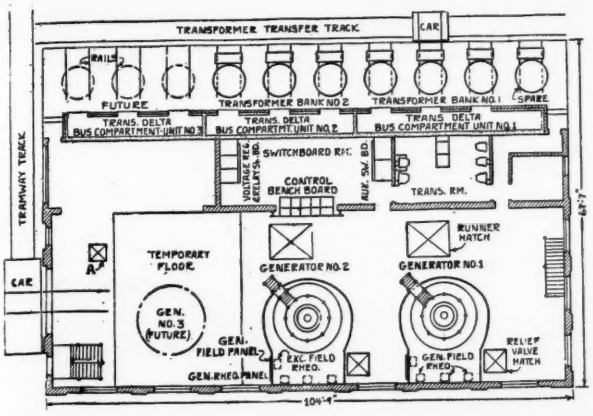


FIG. 5. A PLAN OF THE POWER HOUSE SHOWING THE TWO UNITS NOW IN PLACE AND SPACE PROVIDED FOR THE THIRD

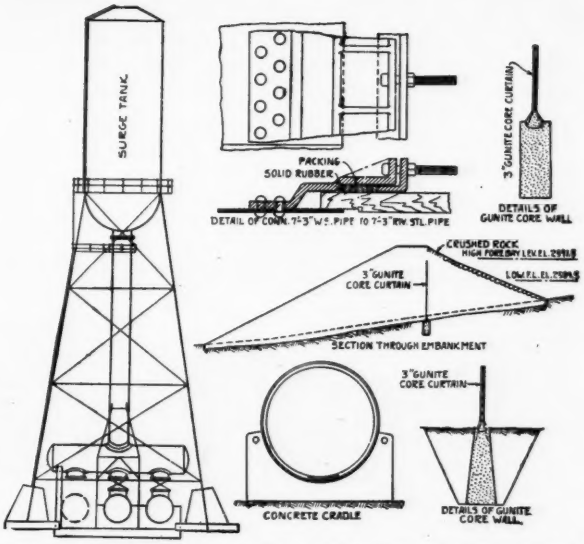

SURGE TANK
PACKING SOLID RUBBER
DETAIL OF CONN. 7'-3" W.S. PIPE TO 7'-3" RIV. STL. PIPE
3" GUNITE CORE CURTAIN
DETAILS OF GUNITE CORE WALL
CRUSHED ROCK
3" GUNITE CORE CURTAIN
SECTION THROUGH EMBANKMENT
3" GUNITE CORE CURTAIN
CONCRETE CRADLE
DETAILS OF GUNITE CORE WALL

FIG. 6. DETAILS AND ARRANGEMENTS OF THE SURGE TANK, CROSS MANIFOLD, JOINT BETWEEN THE WOOD STAVE PIPE AND PENSTOCK, THE FOREBAY EMBANKMENT AND GUNITE CORE WALL

not been in service for a sufficient length of time to determine its ultimate value, present indications are that it is a satisfactory solution of a troublesome problem.

Control of the substation as well as all gates at the dam, forebay and power house is handled from a control room in the power house. This control room, Fig. 8-L, complete with electrical instruments and water level indicators, has, in addition to the remote electrical control equipment, a complete telephone system installed so that communication can be carried on between the power house substation, forebay, diversion dam and other parts of the company's system. Gates at the dam, forebay and power house may be operated electrically or manually as desired.

Switchyard and Substation Built on Plateau Above Power House

Lack of space at the power house for high tension switching equipment, the absence of local distribution lines and low land values largely determined the design

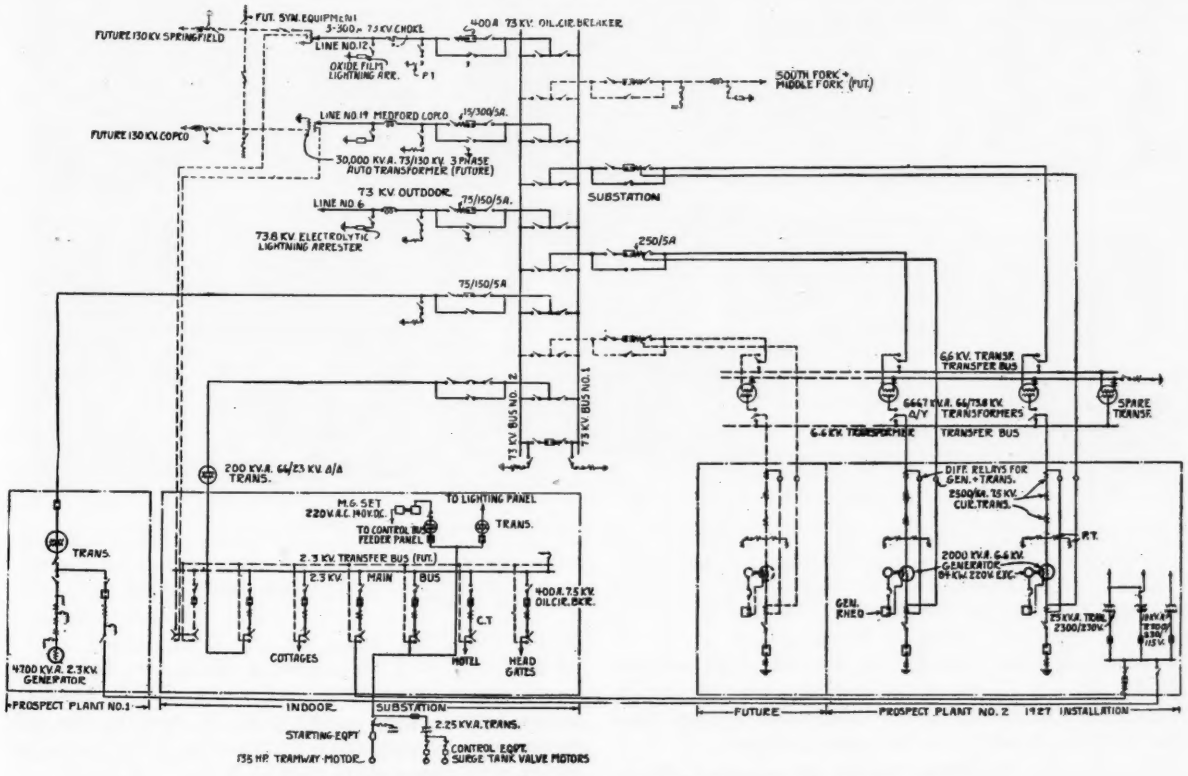


FIG. 7. SINGLE LINE DIAGRAM OF THE ELECTRICAL CONNECTIONS

and arrangement of the electrical equipment. Absence of local distribution lines made it desirable to omit all 6.6-kv.a. buses and switching equipment and connect each generator directly to one bank of three 6667-kv.a., 6.6 to 83.8-kv.a. transformers connected delta star. These transformers, visible in Fig. 8-I are located along the outside wall of the power house with one single phase transformer provided as a spare.

on into the power house where the crane is available. This is accomplished by means of a track, shown in Fig. 5, running the entire length of the transformer platform. From this track the transformer is transferred to the tram car, lowered to the power house door and again transferred to the power house track, where it can be reached by the crane.

Lack of space at the power plant made it necessary

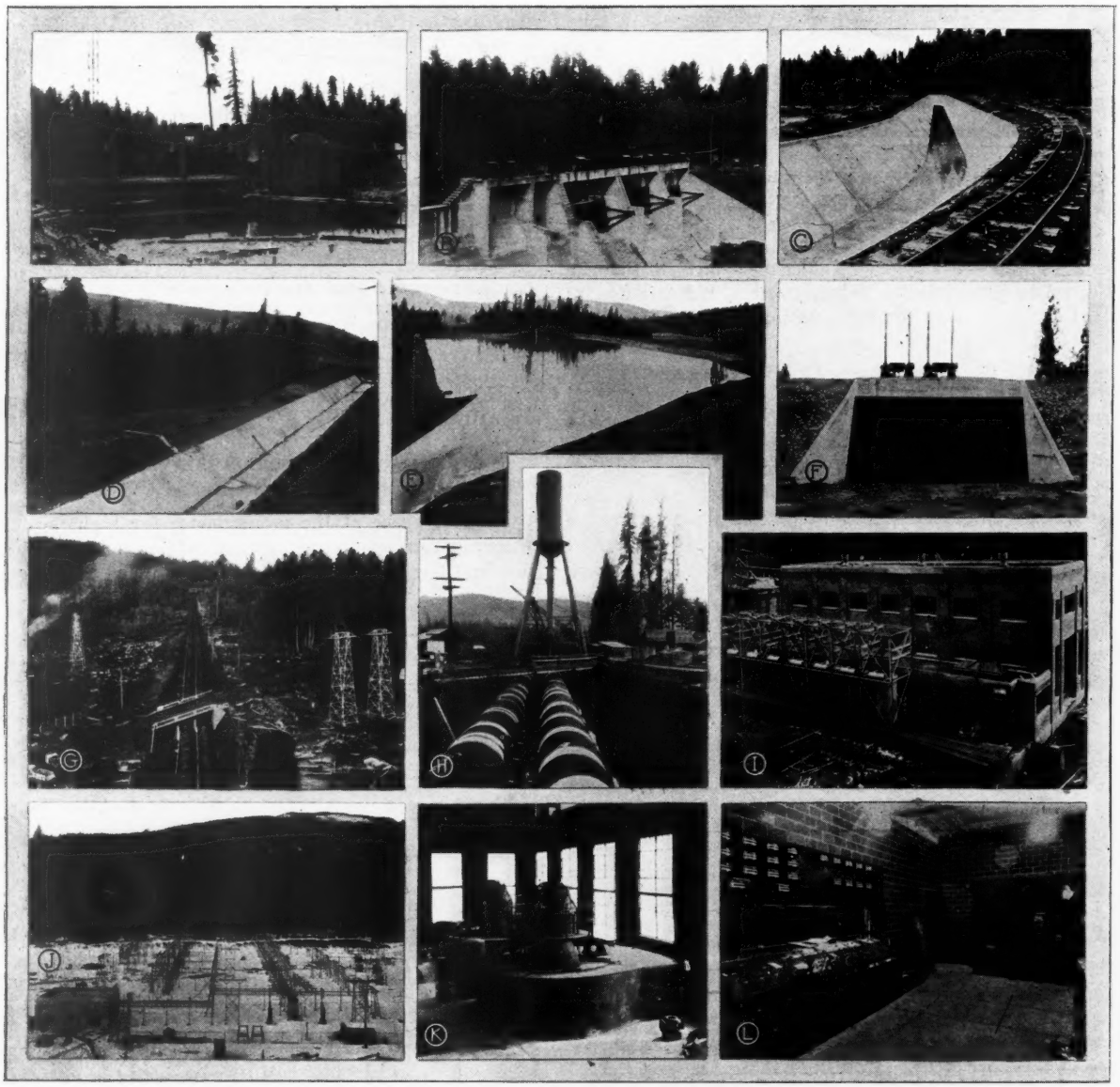


FIG. 8. A.—DIVERSION DAM, UPSTREAM SIDE. B.—DIVERSION DAM, DOWNSTREAM SIDE. C.—SECTION OF CANAL AND NARROW GAGE ROAD. D.—SPILLWAY SECTION OF CANAL. E.—FOREBAY. F.—PIPE LINE INTAKE. G.—WOOD STAVE PIPE, LOOKING TOWARD FOREBAY. H.—SURGE TANK. I.—TRANSFORMER BANK AT POWER HOUSE. J.—SWITCHYARD AND SUBSTATION. K.—INTERIOR OF POWER HOUSE, SHOWING BOTH UNITS IN PLACE. L.—POWER HOUSE CONTROL ROOM

Disconnects are installed on both the high and low tension sides of all transformers so that the spare transformer can be substituted for any one of the other transformers without moving either of them.

In order to facilitate repairs on the transformers provision has been made to take the unit to be worked

to locate the 73.8 kv. switching station on the plateau above, and a lineal distance of about 1500 ft. from the power house. Steel construction is used at the substation and, as property is inexpensive, a low spread-out design with no structure over 31 ft. high was built.

Power for the 2.3-kv. station auxiliary circuit is dis-

tributed from a small substation building which also contains the control battery, battery charger set for oil switch operation, relay panels for the outgoing 73-kv. feeders, lighting panel for the substation and in addition a storeroom and repair shop. A general view of the switchyard and substation is shown in Fig. 8-J.

A double 78.8-kv. bus is used with a 73.8-kv. oil circuit breaker as a tie between them. Connections are shown by a single line diagram, Fig. 7, and details of the switching yard are shown by the full line diagram in Fig. 9, which also includes details of the tower and switching arrangement.

carried down the hill in conduits fastened to the tramway structures.

Construction Methods and Details

Some of the construction methods and details are included in the following paragraphs, for although they are not part of the power plant proper, they form an important part of the project and are of sufficient general interest to be included even though they involve duplication of data presented in the previous summary.

All supplies and equipment had to be trucked in, a distance of about 45 miles from Medford. Due to soil conditions, trucking except on the surfaced highway was impossible, so that after the right of way was cleared, a narrow gage track was built from the camp up to the diversion dam site. A rock crushing and cement mixing plant was erected at the dam and rock was crushed and concrete for the project, as far as the forebay, was mixed at this plant and distributed on the narrow gage by means of cars and gasoline locomotives.

The present diversion dam, about 40 ft. high, shown from both the upstream and downstream sides in Fig. 8, has a concrete portion 230 ft. long, an overall length of about 400 ft. and consists of an embankment, three 34 by 12.5-ft. Tainter gates, a logway, two 4 by 6-ft. sluice gates, the canal intake and another short embankment. The canal intake, which can be seen at the left of Fig. 8-A, is divided and the flow controlled by two 11 by 11-ft. Tainter gates.

No provision for a fish ladder was required by the

Principal Equipment at Prospect No. 2 Hydro Plant

General

Location—On Rogue River, near Prospect, Oregon.
Capacity, present—40,000 kv.a., 80 per cent power factor.
Capacity, ultimate—60,000 kv.a., 80 per cent power factor.
Operating Company—The California Oregon Power Co., subsidiary of the Standard Gas & Elec. Co.
Engineers and constructors—Byllesby Engineering & Management Corp.

Power House

2 Pelton Water Wheel Co. reaction type hydraulic turbines, rated at 23,400 hp. under a 590-ft. head when operating at 514 r.p.m., maximum efficiency 90 per cent at 21,000 hp. Direct connected to
2 General Electric Co. vertical, 20,000-kv.a., 80 per cent power factor, 6600-v., 3-phase, 60-cycle generators with Kingsbury thrust bearings.
2 Pelton Water Wheel Co. oil pressure governors.
2 Pelton Water Wheel Co. 72-in. motor-generated butterfly valves.
7 Westinghouse Electric & Mfg. Co. 6667-kv.a., single-phase, 6.6 to 73.8-kv., oil-cooled transformers, connected delta star.
1 Cleveland Crane & Engineering Co. 60-t. power house crane.
1 Cleveland Crane & Engineering Co. 35-t. tram hoist.
3 General Electric Co. switchboards.
1 Allis-Chalmers Mfg. Co. 35-cu. ft. air compressor.

Switching and Electrical Equipment

7 Pacific Electric Co. Type JB, 400-amp., 73.8-kv. oil switches.
35 Delta Star Electric Co. Type PMB, 300-amp., 73.8-kv., 3-pole, remote mechanically operated disconnecting switches.
1 Electric Storage Battery Co. Type EMG-7, 60-cell, 125-v. storage battery.
1 General Electric Co. 140-v., 1¼-kw. charging set for trickle charging.
1 General Electric Co. 10-panel switchboard at substation.
2 Westinghouse Elec. & Mfg. Co. 200-kv.a., 73.8 to 2.3-kv. transformers connected delta delta.
Lightning arrestors—General Electric Co. oxide film type.

Dam, Forebay and Penstocks

3 Pacific Coast Engineering Co. 34 by 12.5-ft. Tainter gates at diversion dam.
2 Pacific Coast Engineering Co. 11 ft. by 11 ft. 0 in. Tainter gates at canal intake.
2 Link-Belt Co. ¾-in. mesh, revolving fish screens.
2 Pacific Coast Engineering Co. 4 by 6-ft. sluice gates at dam.
3 Pacific Coast Engineering Co. 9 by 11.5-ft. sluice gates at pipe line intake.
2 Redwood Mfg. Co. 87-in. woodstave pipe lines, each 3100 ft. long.
1 Western Pipe & Steel Co. 20-ft. diameter, 48.5 ft. high above balcony, on tower 77 ft. high, surge tank with 82-in. diameter cross manifold and appurtenances.
2 Chapman Valve Co. 54-in. gate valves at surge tank.
1 Chapman Valve Co. 36-in. gate valve for bypass to old forebay.
2 Puget Sound Machinery Depot riveted steel penstocks, 87 in. in diameter, ⅜ in. thick at surge tank, tapering to 72 in. diameter, 15/16 in. thick at butterfly valves, each 900 ft. long and complete with 5 forged, welded slip joints.
12 Multiplex Mfg. Co. Crispen 4-in. air valves.
Gate hoists—D. J. Murray Mfg. Co.

Three 73-kv. outgoing lines, one to Medford, one to Springfield and one to Gold Ray are provided. The first two of these, to Springfield and Medford, will, it is expected, be raised to 132 kv. sometime in the future. In addition to the three outgoing lines, two transformer generator circuits, one station auxiliary circuit and one tie to Prospect No. 1 are provided, with an oil circuit breaker for each circuit. Bypass switches are installed so that the bus tie oil circuit breaker can be used for either one of the other breakers by transferring the circuit to the transfer bus and then through the tie breaker to the main bus.

All disconnects are remote mechanically operated and horizontally mounted and except for the disconnect switches, only strain insulators are used in the substation. Control circuits in steel conduits are run open on special steel columns. Cables from the power house to the switchyard are lashed to messenger supports and

Oregon Game Commission at the dam, as falls immediately below effectively prevent fish from ascending the river. Fish screens are, however, used at the intake to keep fish from the stream above out of the canal. These screens are of the traveling type with ¾-in. mesh, somewhat similar to those used for condenser intakes. Stop logs are provided both before the Tainter gates and after the fish screens.

From the dam water is carried 7000 ft. to the forebay by a canal with a cross section of 144 sq. ft. and a fall of 3.43 ft. to the mile, giving a capacity of 1050 sec. ft.

Part of this canal and the 200-ft. spillway section provided near the forebay is shown by Figs. 8-C and 8-D. The spillway capacity is sufficient to take the full capacity of the canal with an 18-in. flow or the equivalent to a 24-in. rise in the canal. This spillway drains down to a culvert under the highway to the river, a considerable distance above the power house.

A forebay, Fig. 8-E, about 400 ft. square and 20 ft. deep, is provided with two side embankments made with earth excavated from the forebay. They have 6-in. gunite corewalls, details of which are shown in Fig. 6.

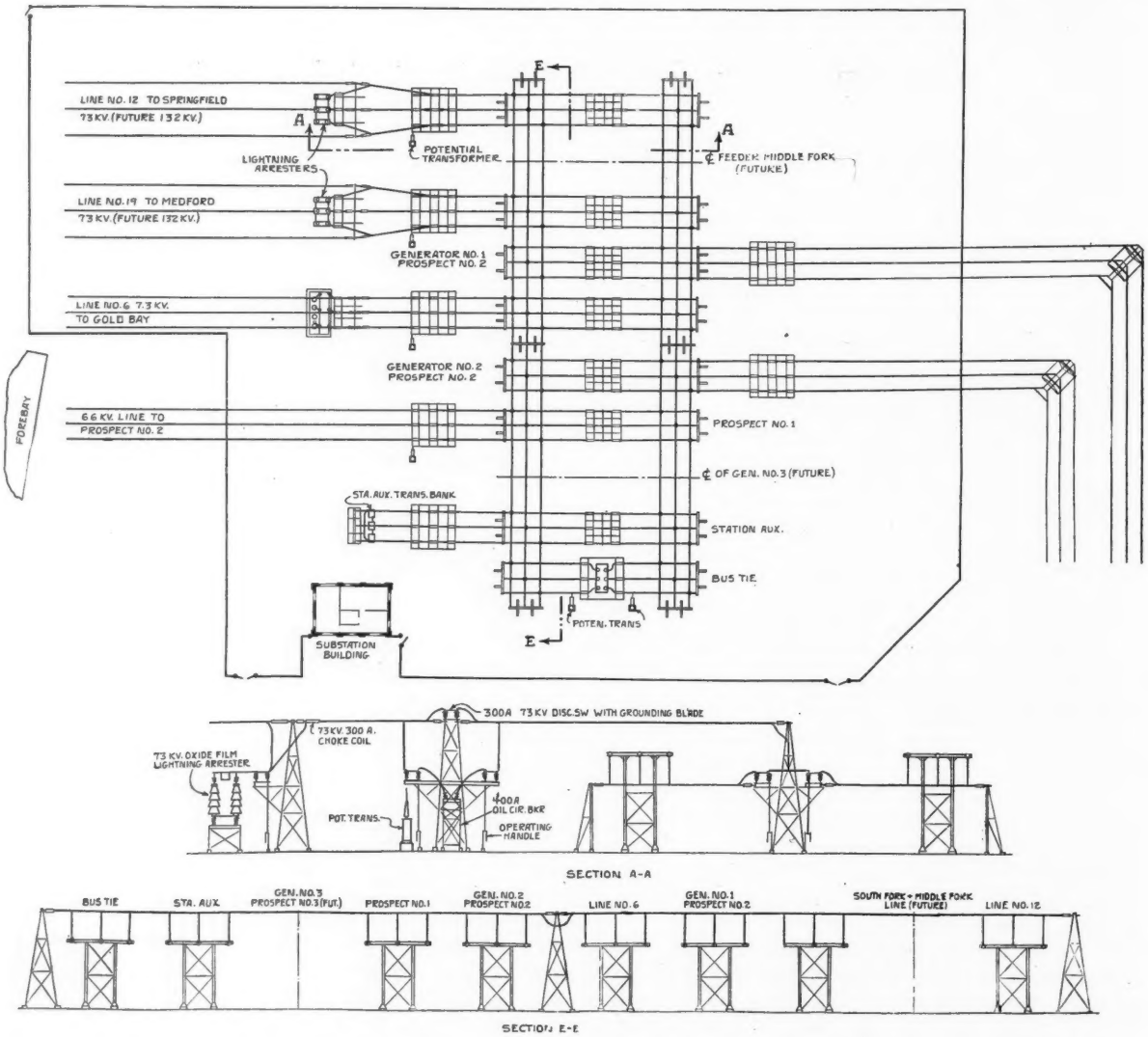

LINE NO. 12 TO SPRINGFIELD
73 KV. (FUTURE 132 KV.)
LIGHTNING ARRESTERS
POTENTIAL TRANSFORMER
℄ FEEDER MIDDLE FORK (FUTURE)
LINE NO. 19 TO MEDFORD
73 KV. (FUTURE 132 KV.)
GENERATOR NO. 1 PROSPECT NO. 2
LINE NO. 6 7.3 KV. TO GOLD BAY
GENERATOR NO. 2 PROSPECT NO. 2
FOREBAY
66 KV. LINE TO PROSPECT NO. 2
PROSPECT NO. 1
℄ OF GEN. NO. 3 (FUTURE)
STA. AUX. TRANS. BANK
STATION AUX.
BUS TIE
POTEN. TRANS
SUBSTATION BUILDING
300A 73 KV DISC. SW WITH GROUNDING BLADE
73 KV. 300 A. CHOKE COIL
73 KV. OXIDE FILM LIGHTNING ARRESTER
400A OIL CIR. BKR
POT. TRANS.
OPERATING HANDLE
SECTION A-A
BUS TIE
STA. AUX.
GEN. NO. 3 PROSPECT NO. 3 (FUT.)
PROSPECT NO. 1
GEN. NO. 2 PROSPECT NO. 2
LINE NO. 6
GEN. NO. 1 PROSPECT NO. 2
SOUTH FORK + MIDDLE FORK LINE (FUTURE)
LINE NO. 12
SECTION E-E

FIG. 9. FULL WIRING DIAGRAM OF THE SUBSTATION, SHOWING THE INCOMING AND OUTGOING LINES AND DETAILS OF THE STRUCTURES

The canal has a flat bottom section of 9.6 ft. with side slopes of 1 to 1 and was lined with 6 in. of concrete. Bottom slabs were poured in 20-ft. lengths and side sections in 10-ft. lengths, using 10 movable forms mounted on wheels and lined with galvanized iron to give a smooth surface. The canal was dug with steam shovels, trimmed by hand and a 6-in. tile drain placed in the bottom before lining.

The pipe line intake, Fig. 8-F, was built for three lines but only two of these are installed at present, although all construction and rock cuts have been made for the third one which will be installed in the future. From the forebay, the 87-in. diameter woodstave pipe lines, 3100 ft. long, protected by 8-in. air valves at the upper and lower end, lead down to the surge tank located on the canyon rim about 115 ft. below normal water level in

the forebay. About 85 ft. of this drop takes place in the first 1100 ft. from the forebay.

At the rim of the canyon, the woodstave pipe is joined to the riveted steel penstock by a slip joint of the type shown in Fig. 6. A surge tank 20 ft. in diameter has been provided at this point and it is connected with both lines by a cross manifold through 54-in. gate valves as shown in Fig. 6. Thus there are no valves or obstruction in the line from the forebay to the butterfly valve at the turbines, yet the arrangement allows any of the pipe lines or penstocks to be isolated and drained. The 36-in. bypass to the Prospect No. 1 forebay is taken from the manifold at the point provided for the future No. 3 pipe line.

Old Plant Kept in Service During Construction of New Plant

Concrete cradles, cast in place every 10 ft., support the woodstave pipe. The line crosses both the highway and the old flume and as the highway department would not consent to raising the roadway, the pipe line was depressed below the highway grade and a bridge, Fig. 8-G, constructed. The old Prospect No. 1 plant had to be kept in operation during construction so that the pipe line was built from each end to the old flume, pre-cast cradles were prepared and, when the rest of the project was finished, the flume was cut and pipe line completed for this small section with a minimum loss of time.

Penstocks are of riveted steel construction, tapering from 87 in. in diameter $\frac{3}{8}$ in. thick at the top to 72 in. diameter, $\frac{15}{16}$ in. thick at the butterfly valve. Five concrete anchors are provided and a forge welded slip joint provided for each section. For a considerable portion of the way from the surge tank to the power house, the drop is almost vertical, as can be seen from Fig. 4. The penstocks for Prospect No. 1 are protected from falling rocks and debris by a covering of logs held in place by cables. This is not altogether satisfactory, so at Prospect No. 2 overhanging cliffs and loose rock were blasted out, leaving a deep cut free from danger of rolling boulders.

Excavation for the power house substructure was carried on without the use of a coffer dam, although it extended considerably below the water level of the river. The formation of the country is volcanic, layers of lava underlaid with cinders were uncovered, indicating that this was in part the original undisturbed volcanic deposit. Bedrock was not reached and a heavy reinforced concrete mat was laid under the entire building to give an even foundation and prevent uneven settling of different parts of the structure.

Both design and construction of the plant was carried out by the engineering and construction departments of the Byllesby Engineering & Management Corp. under the direction of H. W. Fuller, vice president in charge of engineering and construction, and F. H. Lane, manager of engineering and construction. J. William Link, hydraulic engineer, and A. H. Tracy, electrical engineer, had charge of the design and Geo. F. Phythian was superintendent of construction.

Details of the 20,000-Kw. Morrell St. Turbines

Construction and Design Features of Three Turbines Recently Installed in the Municipal Plant at Detroit, Mich.

By G. H. Newton*

LOCATED AT THE FOOT of Morrell and Junction Sts., Detroit, the Morrell Street plant of the City of Detroit, officially placed in service May 23, 1927, was described briefly with a list of equipment in the Nov. 15 issue of Power Plant Engineering. The generating equipment consists of three 20,000-kw., 1800-r.p.m., straight flow Westinghouse steam turbines. These units are designed for steam conditions of 360-lb. gage throttle pressure, 262 deg. superheat and 1 in. of mercury back pressure. The maximum rating of each unit is 25,000 kw. when operating with three stages of feed heating and the best efficiency point is at 17,000 kw. Each turbine drives a 25,000-kv.a., 3-phase, 60-cycle, 13,200-v. generator with its direct connected 240-v. exciter.

All units are erected on structural steel foundations and the weight of the turbine and generator rotors is carried by four self-alining main bearings, two of which are mounted in the coupling housing of the exhaust end of the turbine cylinder, one in the thrust bearing pedestal and one in the outboard generator pedestal.

The turbine cylinder is supported at five points and is anchored at the coupling ends by specially designed king pins bolted to the foundation below the coupling housing and fitted into the cylinder base, thus causing all the expansion of the turbine cylinder to take place toward the governor end of the unit. The exhaust end of each turbine cylinder is carried at the horizontal center line by four supports which are shown in Fig. 2, with a fifth point of support where the high pressure end of the cylinder rests on the thrust bearing pedestal.

This construction allows for transverse expansion of the turbine cylinder at this end of the turbine and since the transverse anchor point is on the same center line as the exhaust end supports, no provision need be made for longitudinal expansion. By supporting the cylinder from the horizontal center line, the vertical expansion is equalized, thus maintaining true alinement of the coupling.

To withstand the pressure and temperature existing in the high pressure part of the turbine, cast steel was used for this end of the cylinder. It is bolted to the cast-iron low-pressure section, proper alinement of the two sections being assured by the use of a rectangular key inlaid in the joints. The low pressure portion is split vertically in order to keep the overall dimensions within the limit of transportation. Both the high-pressure and low-pressure sections of the cylinder are, as usual, split horizontally to allow the removal of the cylinder cover in one piece and the removal of the spindle from the cylinder base. The general arrangement is shown in the longitudinal section, Fig. 3.

Arrangement of the blading is similar to that used

*Engineering Dept., South Philadelphia Works, Westinghouse Elec. & Mfg. Co.

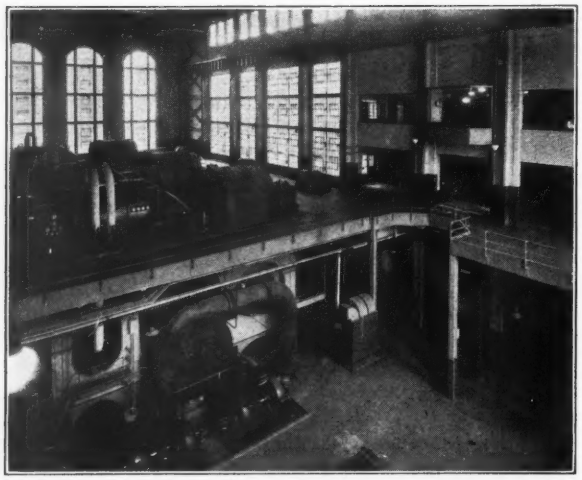


FIG. 1. GENERAL VIEW OF THE MORRELL STREET TURBINE ROOM

in all recent straight flow single cylinder condensing units of Westinghouse design. A portion of the pressure drop through the unit is taken care of in the nozzles, which give the steam a high velocity. Most of the energy equivalent of this velocity is given up in the Curtis element of two rotating rows of impulse blades. The steam then expands through the four groups of reaction blading, some steam being bled off for feed heating after the first, second and third groups, which correspond to the 18th, 38th and 48th rows.

Four Extraction Points Are Provided but Only Three Are Used

Four-stage extraction is provided for, with the high temperature connections made to the chamber between the impulse wheel and the entrance to the reaction blading. In these units, however, this connection is not used.

Blades and dummy rings are so supported in the turbine cylinder as to allow for differential expansion. Two dummy pistons are employed to balance the end thrust of the spindle caused by the difference in pressures over the various areas and the pressure drop over the spindle blading. The spindle dummy pistons are forged integral with the thrust end of the spindle, while the cylinder dummy rings are removable from the cylinder. The smaller of the two dummy pistons is designed to balance the thrust over the first group of blading.

Any steam leaking by the labyrinth strips in this section of the dummy is taken through an equilibrium pipe to the zone where the first bleeder connection is made. This leakage does work in the last three groups of blading. The larger of the dummy pistons is designed to balance enough of the thrust load over the rest of the blading to keep the unit load on the Kingsbury thrust bearing below 250 lb. Steam which leaks by the labyrinth on this dummy is led through another outside connection back to the cylinder at the entrance to the third group of blades where it does work by expanding through the last group of blades to condenser pressure.

Relatively high speeds are used in the last rows of blades. Due to their length, it was necessary to use a tapered blade (one in which the cross section varies) in order to keep the stresses to a minimum. This was accomplished by varying the cross section of the blade in two different ways. In the longest blades, where the stresses are high, the section of the outer part was kept constant (measuring from the tip toward the base). The minimum length of the constant section was determined by calculation. The cross section of the remaining length was varied. In this way blades were produced that have a minimum weight with minimum centrifugal stresses. Using shorter blades and lower stresses the same effect was accomplished by tapering the blade from the base to the tip. Care was exercised to see that the centers of gravity of all cross sections lie on a common vertical axis so that the centrifugal force will produce pure tension and no bending in the blade. The cylinder and spindle blades in the low pressure group are warped or twisted to attain the correct angle to give the steam tangential entry along the edges of the blades in order to obtain higher blade efficiency.

In the three turbines in the Morrell St. Station the first 18 rows of spindle blades and all the cylinder blades except those in the last row are of manganese copper stock that has been rolled and drawn. The last row of cylinder blades is cast manganese bronze and the last 10 rows of the spindle blades are 5 per cent nickel steel.

Steel blades are drop forged and milled at their roots to fit in the retaining grooves, some of which are single tongue, while the last two rows are double tongue. The blades are provided with double tapered tongued wedges on one side to insure a tight fit in the groove. Strips are inserted in a semi-circular groove just below the blade shank, which force the blades against the under surface of the tongue against the main groove, thereby

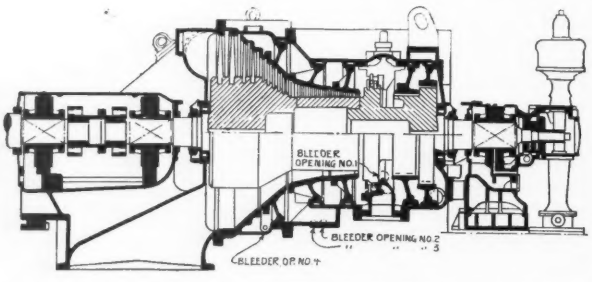


FIG. 3. LONGITUDINAL SECTION THROUGH THE TURBINE ILLUSTRATING THE CONSTRUCTION

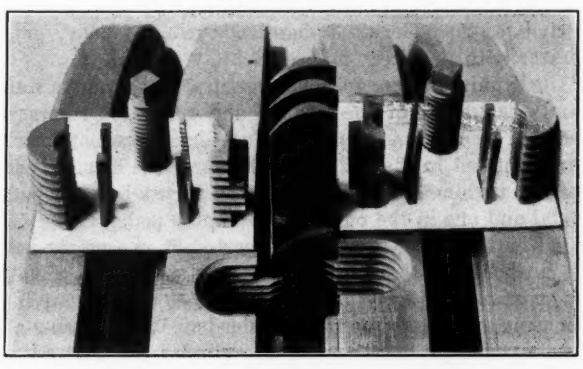


FIG. 4. DETAILS OF THE LOCKING DEVICE USED TO SECURE THE LAST BLADE IN THE ROW

preventing the blade from shifting after the turbine is placed in service. An improved method of locking the last steel blade eliminates the former necessity of omitting two of these important blades in each row. The details of this locking device and assembly are shown in Fig. 4. The semi-circular calking piece and the radii on the supporting faces of the T-shaped root can be easily distinguished.

A Kingsbury thrust bearing is used to secure the proper axial position of the turbine spindle and to take up that part of the end thrust which is not taken care of by the dummy. The entire thrust bearing can be dismantled without removing the spindle from the cylinder. The cage is split horizontally and can be lifted away without removing the disc from the spindle. Oil passages cut radially through the cage supply oil to the

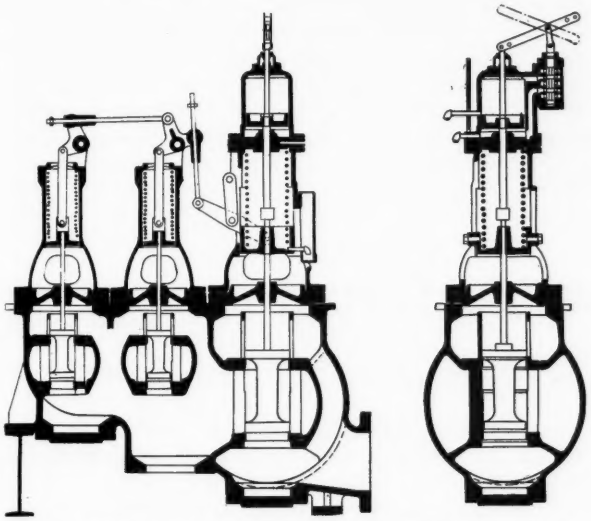


FIG. 5. SECTIONAL VIEW OF THE STEAM CHEST, RELAY AND OPERATING CYLINDER

inner diameter of the bearing. It then passes outward between the thrust collar and the shoes, producing the desired oil film. To insure circulation through the bearing, an overflow orifice plug has been provided. This orifice allows oil to overflow into the governor gear chamber after it passes through the bearing chamber.

Turbine spindle ends, where they come through the cylinder, are sealed against leakage of steam outward or air inward by water seal glands. Water is fed into the gland cases bolted to the ends of the turbine cylinder. The gland runners or impellers, which are fastened to the spindle, revolve in annuli in the gland casings. The water is supplied to the entire periphery of the gland runner through cored passages in the casing. This insures a solid ring of water around the shaft and the pumping action of the runner maintains sufficient head to prevent leakage inward or outward. This type of gland calls for continuous circulation of water through the runner chamber.

Pin type couplings, now standard for all 1800-r.p.m. turbines of 25,000-kw. maximum capacity or less, are used on the Morrell St. turbines. The governor is the standard Westinghouse flyball type of improved design. It is mounted on the thrust bearing pedestal and driven by a worm gear, geared to the end of the turbine spindle and meshing with a worm wheel which is keyed to the lower end of the governor spindle.

Steam Chest Mounted on Steel Support Near Turbine

Steam chest and throttle valve, shown in Fig. 5, are mounted on structural steel at the side of the turbine. One end of the steam chest is fastened rigidly to the foundation steel, while the other end is supported by a flexible I-beam construction to take care of the expansion. The primary, secondary and tertiary inlet valves are mounted in the steam chest and are all under gov-

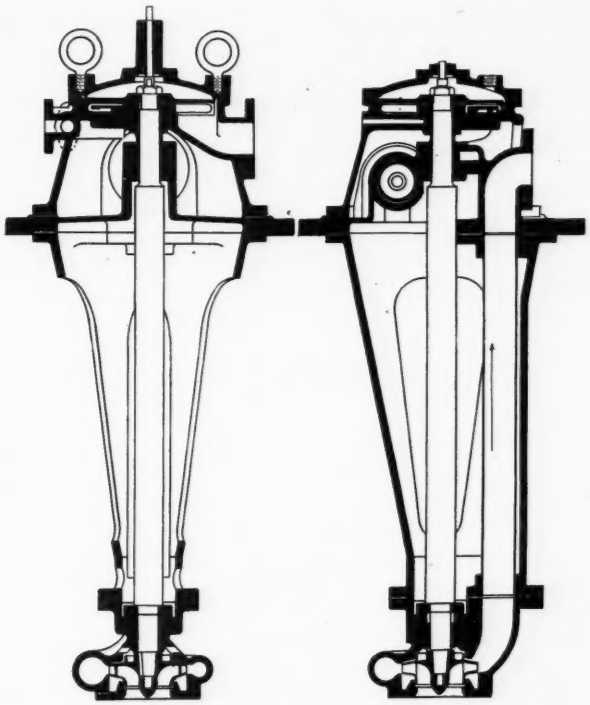


FIG. 6. CROSS SECTIONAL VIEW SHOWING THE CONSTRUCTION OF THE TURBINE-DRIVEN AUXILIARY OIL PUMP

ernor control. All steam entering the turbine first passes through the primary valve, which is not only under governor control through an oil operated piston, but is also spring loaded, as are the secondary and tertiary valves to insure positive closing in case the load is lost.

Steam chest valves are of the double seated poppet type with ports designed to pass the required steam at a moderate velocity. The secondary valve, through its linkage, is set to start opening when the primary inlet pressure is within 10 lb. of the throttle pressure and the tertiary valve will also start opening when the secondary inlet pressure is within 10 lb. of the primary pressure.

Steam inlet pipes are reduced in size between the steam chest and the turbine cylinder through the application of nozzles which bolt into the outlet from the steam chest and diffusers on the steam inlet connections to the nozzle chambers. Owing to the employment of the Venturi principle of expansion and recompression, the

reduced pipe size gives little higher pressure drop between the steam chest and the turbine nozzles than the normal size and provides a far more flexible arrangement of piping.

Long sweeping pipe bends allow sufficient flexibility in the steam inlet pipes to relieve the steam chest and turbine cylinders of strains due to expansion of the apparatus. The primary nozzles are located in the cylinder base and the primary inlet steam line is taken from the under side of the steam chest to the primary nozzles, making a long loop under the floor. The secondary and tertiary connections are taken off the side of the steam chest adjacent to the turbine and the long loops extend upward and over to their respective connections in the cylinder cover.

The automatic throttle valve is bolted directly to the steam chest and spring supported to relieve the steam chest of strains due to the lever effect resulting from its overhanging weight. The main steam line is so fabricated and supported that there will be no danger of force exerted on the throttle valve and the steam chest. The valve is equipped with an automatic closing device actuated by an automatic stop mounted on the extreme end of the turbine spindle directly below the governor. This automatic stop is set to operate when the turbine speed increases 10 per cent above normal.

Two Oil Pumps Provided

Oil for lubricating the turbine and governor bearings, as well as high pressure oil for operating the valve gear while the unit is in service, is furnished by a three-pinion gear pump driven from the main governor through a special coupling arrangement on the lower part of the governor worm wheel, and the oil pump shaft. The pump is submerged in the oil reservoir and is supported from the lower part of the thrust bearing housing just below the governor.

An auxiliary oil pump shown in cross section in Fig. 6 is used to supply oil to the bearings and valve gear when starting up or shutting down the unit. This is a turbine-driven centrifugal pump mounted on top of the oil reservoir and submerged in the same manner as the main pump. The turbine rotor has a single row of buckets and drives the oil impeller through a direct connected shaft at 3500 r.p.m. An indicator projecting from the top of the auxiliary turbine housing was provided so that the operator may readily determine whether or not the pump is running. This pump is automatically controlled when the turbine is in service and any tendency for the bearing oil pressure to drop below a predetermined amount will result in steam flow into the turbine nozzles and bring the auxiliary oil pump into service.

Testing and Care of Venturi Meters

Part II.* General Notes on Some of the Factors Affecting Operation of Venturi Meters; Use of the Special Venturi Planimeter. By Fred Emmarr

IN THE LIGHT of the directions given in Part I of this article, the following notes on the liquid Venturi meter should be of interest. As has been pointed out, these cover all possible contingencies and it is not implied that any or all of the difficulties mentioned will occur in any one meter or with great frequency. It will be noted that many of the following comments refer to conditions external to the meter and to matters for which the operator is responsible, or to conditions of installation.

1. Fluctuation in Flow

Fluctuations in the rate of flow through the Venturi tube affect the accuracy of the meter and tend to produce too high a reading. In the boiler house this may be due to the use of a reciprocating pump or to quick changes in load, etc. This error may run higher than 10 per cent. The writer has seen three separate cases where the meter has apparently read 10 per cent higher than the possible displacement of the duplex feed pumps.

The manufacturer recommends the use of very large air chambers to counteract this error.

2. Vibration of Meters

This should be reduced to a minimum by proper foundation and bracing. Transmission of vibration of the water line due to a reciprocating pump can be reduced by bracing the meter lines.

3. Cleaning the Tube

Considerable error may be introduced into the meter should the tube gradually become incrusted with scale. This reduces the area of the tube, particularly at the throat.

The tube should be opened and cleaned once or twice a year if convenient, according to the condition of the boiler water. Large underground tubes cannot, of course, be removed for cleaning, but these should be blown down regularly.

The meter lines should be blown down at least once a week. It can be noticed that the readings usually drop a little when blown down.

4. Freezing

In cold weather, Venturi meters are subject to freezing and bursting. If the meter cannot be protected in a warm building, a steam line should be placed around it, or a coal or coke fire, if gas is unavailable. If no heat is practical, the meter should be drained and left empty until the danger of freezing is past.

5. Regularity

The meters should be checked regularly, say once a week when blown down. It is rather poor policy to wait until an error is noticed and then check the meter.

Not only should the meter be checked in itself, but the properties of the fluid measured also, such as its temperature, density, etc., so that the maximum usefulness and accuracy are obtained.

A regular form should be made up and filled out each time these data are taken. The accompanying form is the type used for liquid meters.

*This is the second and last part of the above article. Part I was published on pages 286 to 288 of the March 1, 1928, issue of Power Plant Engineering.

Calculation of Corrections on Venturi Meters Measuring Liquids

1. Temperature of Liquid Measured

Each meter is designed for a given liquid at a given temperature. For example, the water meters are designed for water at 65 deg. F. The actual temperature of feedwater measured at the boiler house is about 210 deg. F., which makes quite an error if read directly. On the accompanying curve, correction may be made for various temperatures of water in percentage.

2. Density of Liquid Measured

Each meter is designed for a given liquid of given specific gravity, and proper correction must be made for

Venturi Tubes: _____ Data Taken by:
Chart No. _____ Calculations by:

New data taken: Present factors determined:
Data last taken: _____ New factor calculated: _____
Interval Interval

CORRECTION DATA: CORRECTION

Feedwater Temperature through Venturi Tube: _____ _____%
Venturi Throat Diameter____in. _____%
Density of Liquid:
(a) Differential Correction: _____%
(b) Volume Correction: _____%

Over all Correction Factor_____%

STANDARD CONDITIONS:

Feedwater Temperature through Venturi Tube: 62 deg. F.
Venturi Throat Diameter: in. Inlet Diameter in.
Density of liquid: Water at 39 deg. F. 1.000.

PLANIMETER CONSTANTS:

CHART DIVISION	NET PLANIMETER READING	CONSTANT	AVERAGE FOR DESIRED ZONES	AVERAGE TIMES CORRECTION FACTOR

NET CORRECTED CONSTANTS:

RANGE	NET CONSTANT

Approved: _____
Date

FIG. 1. FORM USED IN CHECKING ACCURACY OF LIQUID VENTURI METERS

deviations from this standard. For example, if using ammonia liquor of density of 1.05 in a water meter designed for 1.00 liquids, and reading in pounds, considerable error is introduced in two ways:

(a) Differential correction: The volume of liquid passing through the meter tube varies directly with the square root of the differential pressure, i.e., upstream head—throat head. Since the pressures vary directly with the density of liquid, the volume of liquid then varies directly with the square root of the density of the liquid, so that on a meter set for 1.000 the increased differential would give too high a reading. Hence the correction would be inversely as the square roots of the densities.

(b) Volume correction: The meter measures volume and calculates pounds, etc., so that if the meter is designed for liquids of 1.000 specific gravity, the correction would be directly as the densities.

3. Variation in Venturi Tube Areas

After long periods of operation, the inside of the Venturi tubes becomes covered with an incrustation, hard or soft, and the areas of the tubes vary and produce an error in the meter.

(a) Upstream: For this plant, this error is negligible, for with our periodic inspection of the tubes, a maximum coating would be ⅛ in., which, with such a large area, would have but little effect on the differential pressure that reaches the meter.

(b) Throat: With the small throat, however, ⅛ in. coating would introduce considerable error. The velocity through the throat varies inversely as the area. The quantity of liquid indicated on the chart varies directly as the velocity and the square root of the differential pressure, and the latter varies inversely with the area. Hence the recorded volume of liquid on the chart varies inversely with the area of the throat, so that with a dirty throat, the reading should be reduced by the ratio of the areas of the throat, dirty and clean.

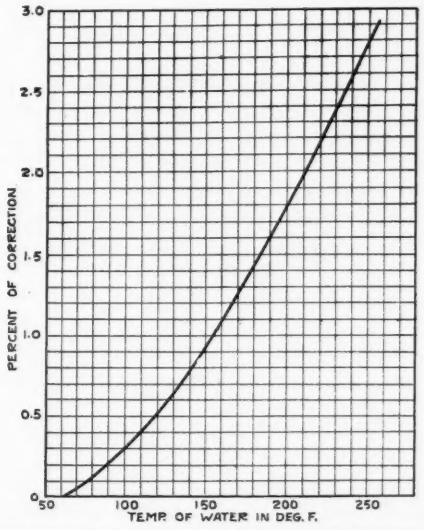


FIG.2. CURVE FOR THE CORRECTION FOR TEMPERATURE

(c) This can be checked by cleaning the tubes when determining the areas and watching the operation of the meter immediately before and after such cleaning.

4. Miscellaneous Corrections

Large variations in temperatures of the instruments, mercury, racks, etc., may introduce small errors.

The Venturi Meter Planimeter

In the directions issued by the manufacturer for the special Venturi meter planimeter, using the celluloid zone disk, separate constants for the respective zones, multiplied by the net planimeter readings, with no zero correction, gives the flow per day.

After years of operation, however, an error develops in this arrangement, due possibly to the wear of the wheel, and other mechanism. The following tests on one planimeter were made:

1. Checking the constant of the planimeter by integrating the required circle, 6¾ in. diameter, which gave a reading of 493 against the given constant of 510.

2. By calculating constants for certain zones, by integrating a given division, as 100,000 lb. per hour, and dividing the value of this division multiplied by 24 hr., by a planimeter reading thus:

Division	Total for 24 hours	Zone	Pla. rdg.	Constant	B.I.F. constant	Per cent error
100,000	2,400,000	B	264	9091	8626	5.4
200,000	4,800,000	C	546	8791	8609	2.1

Hence the method developed for interpreting the planimeter readings was as follows:

1. Planimeter the various main divisions across the chart, such as 100,000, 200,000, etc.

2. Multiply the value of these divisions by 24 to give their 24-hr. equivalents.

3. Plot the planimeter readings against the 24-hr. values.

Then the daily results can be obtained directly from these curves without corrections of constants. By repeating the process and making up new curves every year, any variations of the planimeter can be taken care of.

Where the operation throughout the entire year is fairly uniform and the meter reads between certain divisions, it is best to magnify the curve and planimeter readings by plotting the points between the limits of operation, eliminating the portion of the chart to zero or the end of the chart. This gives closer readings on the planimeter.

If a constant for multiplication is desired, the constants obtained by dividing the 24-hr. division reading (2,400,000 on the preceding example) by the planimeter reading (264), should be averaged for the operating range and used. For example, in the foregoing case, had the two constants, 9091 and 8791, been averaged for a result of 8941, the error between the two limits would have been less than 0.5 per cent.

In using these curves or constants, all other correction factors could be included in the constant, giving a direct reading or multiplier.

For example: On the accompanying meter calibrating form, under "Correction Data," the various conditions of the meter that are not standard are tabulated. These include feedwater temperature, possible Venturi throat incrustation, density of liquid, etc., as explained under "Calculations of Corrections."

Then below are found "Planimeter Constants," which are derived as just explained. The "Average for Desired Zones" is multiplied by the correction factor obtained for the above conditions, called the "Overall Correction Factor," to obtain "net corrected constants."

Then, for final use as a multiplier in the daily chart interpretation, the "net corrected constant" for the operating "range" is selected and placed apart for quick reference as the "net constant."

Such an arrangement places the important phase of meter reading on a regular routing basis, with simple standardized procedure.

THE RED RIVER LUMBER CO., Westwood, Calif., is planning a $250,000 hydro-electric project on Ash Creek in Modoc County, Calif.

How to Find the Ignition Point of Powdered Coals

SOMETIMES it is desirable to test the ignition point of various grades of coal of the same size particles, or of various sizes of coal of the same kind. Wilhelm Schultes describes a method for securing this information which is similar to the method of determining the ignition point of products of the degasifying process, as used by K. Bunte and A. Koelmel and described in Gas und Wasserfach.

The heating element consists of a clay tube 23.6 in. long, 0.98 in. wide on the inside, and of 0.0787 in. wall thickness. A wire is wound around this tube and covered with asbestos packing 1.57 in. thick. Then a tube of potash glass having a high melting point is filled halfway with shard to facilitate uniform heating of the air flowing through it. This tube is then inserted in the clay tube.

Above the tubes is a set of three narrow-meshed wire sieves on which 1 gram of the coal sample is placed. A thermo-element of platinum-platinumrhodium is so passed through the glass tube that its soldered point is 1.5 mm. above the sample of powdered fuel. The temperature is measured with a millivoltmeter. The heat-flow is controlled with a resistance and measured with an ammeter.

The air is drawn through the apparatus by means of a water jet pump, but first it is passed through a gas meter, carefully dried in washing flasks containing concentrated sulphuric acid, and in chloride of calcium crystals and the CO_2 extracted by means of sodium-carbonate. The air flows then through the potash glass tube and through a reacting glass which is filled with a saturated solution of $Ba(OH)_2$. This solution should prove that there really is combustion at the moment when the increase in temperature shows the start of ignition. For, when CO_2 passes through, $BaCO_3$ is formed, which deposits in thick flakes. At the same time, by making a test in advance, the reacting or test tube proves whether all CO_2 had been extracted from the air to be used.

Before the tests started, test curves were obtained for the oven, by heating the empty oven with a uniform current of 2 amp. and with various amounts of air. The variations were but small. The other tests were given under constant air supply of 63 quarts per hour. The coal dust samples were tested on standard testing sifts and divided into four groups as follows:

A. Quantity passed through the 10,000 mesh screen.

B. Quantity through the 6400 mesh screen and residue to the 10,000 mesh screen.

C. Quantity through the 4900 mesh screen and residue to the 6400 mesh screen.

D. Quantity through the 900 mesh screen and residue to the 4900 mesh screen.

Each of these groups was tested as follows: The 1 gram sample was placed on the potash glass tube screens. Air was then drawn through the tube and proof obtained that no CO_2 was left in it. Then a normal air flow was maintained and the heat flow turned on at 2 amp. The millivoltmeter was read at constant intervals. The temperature rose gradually, as in the

*Abstracted and translated from Archiv. fuer Waermewirtschaft.

test, and then rose suddenly when the reacting tube showed the start of combustion. The results were rechecked by cooling and reheating.

In this case coal from Rheinland-Westphalia was tested. Regardless of the speed of air flow, the ignition point for the same size of coal was higher, the older the coal or the less combustible. The surface conditions of the particles of coal affect the ignition point. For instance, anthracite repels heat more easily than poorer grades. The ignition point rises with an increase in the size of grain. Ignition depends more on the grain than on the content of combustible. Accordingly, a fine-grained powdered poor grade coal would give less trouble in pulverized firing than a coarsely ground rich or gas flame coal. However, further investigations on the ignition point of coals of various grains and kinds are to be made.

For the coal samples of the Rheinland-Westphalia coal the ignition points were as follows, the letters A. B. C. D. corresponding to those in the mesh-width of the sift:

A. Between 150 and 240 deg. C.
B. Between 330 and 500 deg. C.
C. Between 450 and 580 deg. C.
D. Above 550 deg. C.

Solvay Process Company Uses High Pressure

Two 120,000 Lb. Per Hr. Steam Generating Units and High Back Pressure Turbines Supply Power and Process Steam

PROBABLY the most interesting industrial power plant that has yet been installed is at the Solvay Process Co., Solvay, N. Y. The plant was put into service last year and has been in operation for several months, furnishing power and process steam.

The installation consists of two combustion steam generators with Elesco superheaters, Copes feedwater regulator and Hydrojet ash conveyors, supplying steam to Westinghouse 4750-kw. turbines, operating against a back pressure of 125 lb.

From the standpoint of design, the steam generator itself, shown in cross section in Fig. 1, is somewhat

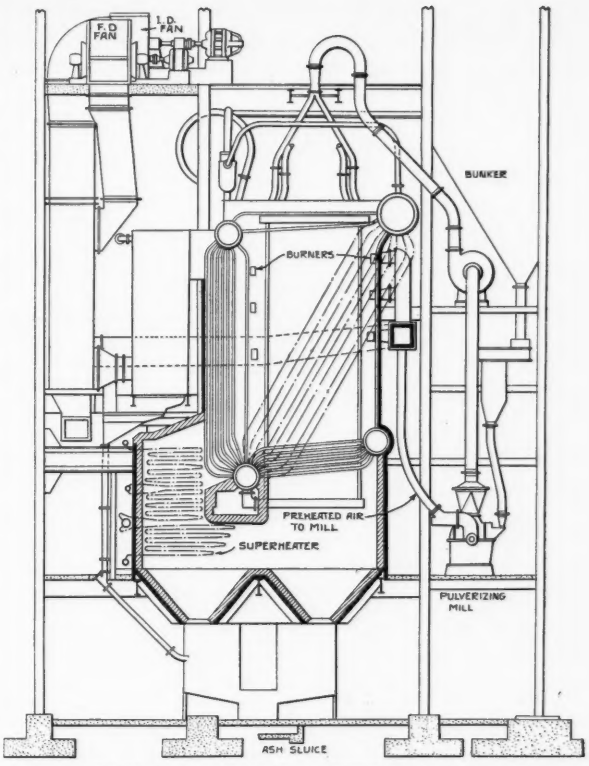


FIG. 1. CROSS SECTION OF THE INSTALLATION SHOWING THE ARRANGEMENT OF EQUIPMENT INCLUDING THE ECONOMIZER AND AIR PREHEATER

similar to the steam generators at the Morgan & Wright plant described in our February 1 issue and at the A. E. Staley plant described in our February 15 issue. The arrangement of the pulverizer, exhauster fan differs from either of the other two plants, however, and an economizer precedes the air preheater.

Four burners firing tangentially are used. The furnace is entirely water cooled; the gas of combustion passes down through the superheater up through the convection section of the boiler, down through the economizer and up through the air preheater to the induced draft fan and the stack. Air for combustion is forced down through the air preheater, through the

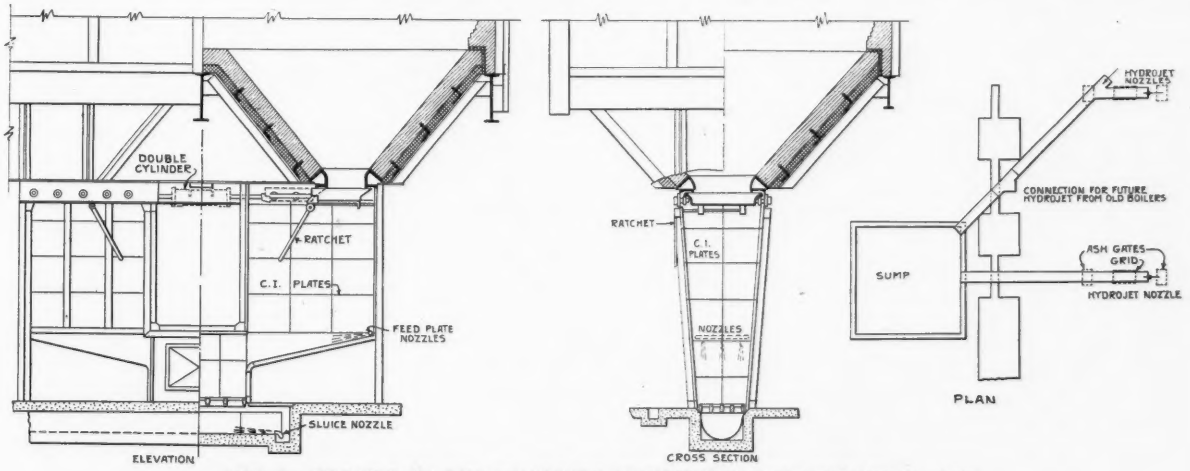


FIG. 2. DETAILS OF THE HYDROJET SYSTEM USED FOR REMOVING ASH

ducts surrounding the steam generator, and into the furnace through ports around the burner. Primary air for combustion taken through the mill is also supplied from this duct.

Superheaters are designed to superheat 120,000 lb. of steam per hour to a final temperature of 735 deg. F. or what is equivalent to 215 deg. superheat at 804 lb. pressure. The superheater units differ from usual practice in that a thicker gage tubing is used and the headers are of special construction, each header being forged separately. Unlike the Morgan & Wright and A. E. Staley Co. installations, the superheater units are placed horizontal instead of vertical.

Ashes Removed by Water Sluice

Details of the Hydrojet ash removal system are shown in Fig. 2. Once each day the power-driven ash gates are opened and the ash accumulation on the furnace bottoms is allowed to drop on the slightly sloping feed plates immediately beneath. From this point the ashes are washed by means of feed nozzles, through heavy cast-iron grids directly over the sluiceway, as indicated on the drawing.

They are carried along this sluiceway into a sump, and from this sump they are raised approximately 30 ft. and pumped a distance of about 600 ft. for fill by means of a Manganese steel pump, driven by a 40-hp., 900-r.p.m. motor. The water consumption in the sluiceway, including the feed nozzles is furnished at 100 lb. pressure and should not exceed 600 g.p.m. when moving ashes at the rate of 25 t. per hr. The system is entirely enclosed to prevent dust, fog or water from entering the ash basement.

The only labor involved in emptying the ash hoppers is the turning of the four-way cocks to open the ash gate doors and the starting and stopping of the pumps. One man, working considerably less than an hour a day, can take care of the ashes from the two steam generators and deliver them to a point 600 ft. distant from the power house. The total power cost is approximately 2c per ton of ashes and to date there has been no maintenance in connection with the ash handling equipment.

This installation in the industrial field ranks in importance with the initial 1200-lb. installation at Edgar and Lakeside. Final tests and operating figures, when they are published, will undoubtedly have an important influence on industrial power plant application and design in the future.

Generating Capacity in Dixon Station Increased

New 12,500-Kw. Turbine Installed to Operate 212-Lb. Gage Until Old Equipment Is Removed, the Pressure Will Then Be Increased to 375 Lb. Gage

STEADY ADDITION to the connected load and increased consumption of present public utility customers due to the industrial growth in Northern Illinois made it necessary for the Illinois Northern Utilities Co., Dixon, Ill., to make considerable extension of their distribution system and install additional steam generating equipment to supplement their present steam generating and hydro generating station.

One of the most interesting of the company's installations is the 12,500-kw. steam turbine added to the steam plant. This station, which was described in the February 15, 1919, issue of Power Plant Engineering, originally had a total generating capacity of 4500 kv.a. Later this was increased to 6000 kw. by the installation of a new turbo-generator and new boilers.

The boiler equipment of the original station and its first addition was designed to operate at 225 lb. gage, 200 deg. superheat. The generators were connected to a low voltage bus, the transformers serving either unit. The new 12,500-kw. turbine, shown in Fig. 1, increased the plant capacity to 18,500 kw. The new generator is connected directly to the low voltage side of three 6000-kv.a. water-cooled single phase transformers. The new unit was installed in the original plant with the intention of removing the smaller low pressure turbines sometime in the future and replacing them with a 12,500-kw. or larger machine.

For this reason, the new boilers and turbo-generators are designed for 375 lb. gage, 250 deg. superheat, although they are now operated at 225 lb., 200 deg. superheat so that the old and new boilers and all three turbines can be operated in any combination desired.

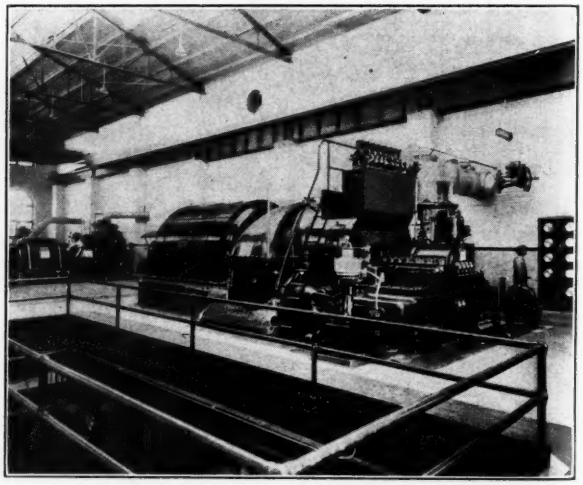


FIG. 1. VIEW OF THE NEW 12,500-KW. TURBO-GENERATOR INSTALLED IN STEAM STATION IN DIXON, ILL.

When the old turbines and boilers are removed, the operating pressure will be raised to 375 lb. and the superheat increased to 250 deg.

Boiler room, turbine room and screen house design is well illustrated by the cross-sectional drawing shown in Fig. 2. Two 7502-sq. ft. boilers with superheaters and economizers are fired by chain grate stokers. The economizers have a heating surface of 3648 sq. ft. The turbo-generator is a 12,500-kv.a., 80 per cent power factor, 1800 r.p.m., 375 lb. gage, 200 deg. superheat, 11,400 v. three-phase, 60-cycle machine with turbine designed

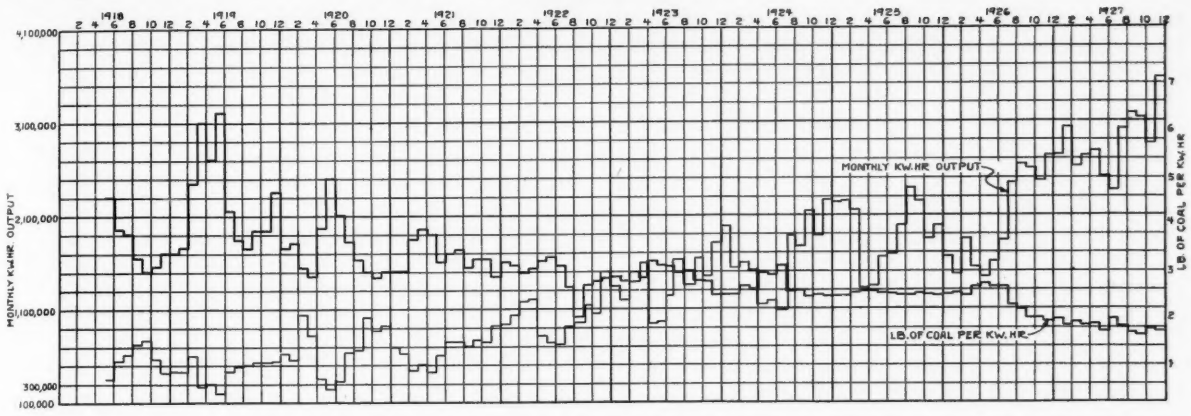


FIG. 3. CURVES OF THE STATION OUTPUT IN KILOWATT-HOURS AND PLANT PERFORMANCE IN POUNDS OF COAL PER KILOWATT-HOUR GENERATED

for bleeding at two points for feedwater heating. The turbine is set over an 18,000-sq. ft. surface condenser, served by one 20,000-g.p.m. motor driven circulating pump. Twin air ejectors with a total capacity of 20 cu. ft. per min. at 2.5 in. absolute are installed. Condensate is handled by two 2-stage, 6-in., 400-g.p.m. centrifugal motor driven condensate pumps which remove the condensate from the hotwell, pump it through the generator air coolers, the ejector inter and after cooler, through the bleeder heaters to the open feedwater heaters.

As shown in Fig. 3, the operating record of the station measured in pounds of coal per kilowatt-hour has improved steadily until it is now well below 2 lb. The final large reduction during the fall of 1926 indicates the installation of the new 12,500-kw. machine. Just what effect the addition of this unit on the station had is well shown by the comparison of the operating figures for February, 1926, and February, 1927, as given in Table I.

The new equipment which was put into service August 10, 1926, reduced the heat consumption of the station from 28,750 to 21,009 B.t.u. per kw-hr., or almost 27 per cent. As can be seen from Fig. 3, February, 1926, represents a low point in the plant operation and February, 1927, a high point, the respective station load factors for the month in 1926 and 1927 being 35 and

TABLE I. SHOWING THE EFFECT OF THE NEW UNIT ON THE HEAT ECONOMY OF THE STATION

Item	February, 1926	February, 1927
Rated capacity, kw.	6,000	18,500
Rated capacity of boilers, b.hp	2,750	4,250
Total generated, kw-hr.	1,486,400	3,027,000
Maximum hourly generation, kw	6,300	11,000
Maximum 15 min. peak, kw	6,300	12,000
Power factor, max. hr	85	98
Voltage through bus	2,460	2,370
Station load factor	35	40.9
Station operating capacity factor	58	42
Station service factor	100	87.2
Average heat transfer, B.t.u. per sq ft. of heating surface	4,266	3,920
Steam pressure—main unit, lb. gage	193	195
Superheat—main unit, deg. F.	172	178
Exhaust pressure—main unit, in. abs.	.36	.325
Total water evaporated	27,667	38,955
Makeup water, per cent	11	4.6
Kind of fuel	Lump	Lump
Cost of fuel in bunkers, per t.	$4.66	$4.39
Cost of handling fuel, per t.	$0.05	$0.044
Cost of refuse removable, per t.	$0.104	$0.033
Fuel in storage, t.	5167	5617
Fuel fired, M. t.	3788	5529
B.t.u. per lb. as fired	11,500	11,500
Boiler efficiency, per cent	72	73.2
Steam per kw-hr. output, lb.	20.3	13.1
Fuel per kw-hr. output, lb.	2.50	1.83
B.t.u. per kw-hr. output	28,750	21,009

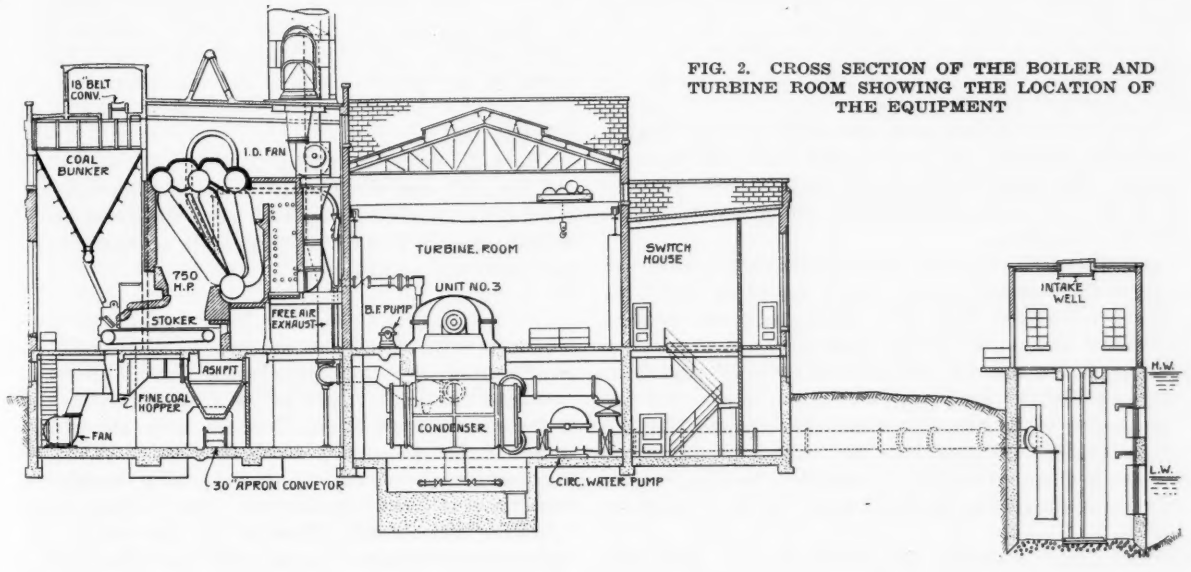


FIG. 2. CROSS SECTION OF THE BOILER AND TURBINE ROOM SHOWING THE LOCATION OF THE EQUIPMENT

40.9 per cent. For the months of March when the station load factors were 38 and 34 per cent respectively for 1926 and 1927, the B.t.u. per kw-hr. dropped from 28,750 to 22,450, or about 22 per cent.

During the year 1926, the output of the station increased from 1,677,700 kw-hr. in January to 2,705,500 kw-hr. in December, with a corresponding reduction in production cost from $0.0079 to $0.0058 per kw-hr. This difference was due largely to lowered fuel costs.

These values, of course, represent extreme months. The average saving as computed by the engineer several months after the new unit was put into operation amounts to about $0.0016 per kw-hr. This calculation makes no allowance for variations in the coal cost but is based on increased boiler efficiency of from 70 to 73.5 per cent and a reduction of water rate from 13.25 to 11.50 lb. of steam per kw-hr. This cuts the fuel cost per kw-hr. from $0.00593 to $0.00486. Actually the plant efficiency is being gradually increased from month to month, making it difficult successfully to predict fuel savings which might be expected.

Gluttons for Punishment

"WELL, if I'm not a glutton for punishment!" growled a voice in the editor's ear as that worthy sat in the engineering society's lecture hall, puffing contentedly on his pipe and waiting for the lecture on Turbo-generators to begin. Without looking around, the editor immediately recognized the voice as belonging to his neighbor at the previous meeting, the gray-haired, thick-set man who had grumbled so lustily about the speaker's long introduction.

"Yes, sir!" continued the thick-set man, seating himself beside the editor and lighting his pipe, "I always come back for more. I realize that somewhere, sometime, even if the lecture isn't much good, I may pick up a little dope I can use. Then, too, it gives me a chance to meet the boys and talk about the new Ford and how I got Australia on the loud speaker last night. That's worth a whole lot."

He puffed at his pipe while the chairman introduced the speaker of the evening. Suddenly he growled, "Ye gods! he's gonna read the thing from a manuscript! If there's any better way of putting an audience to sleep, I don't know it. Oh, well, I'm here now, so I guess I'll stay a while."

After about 20 min. of somnolent silence, during which the lecturer had read steadily from his paper in a thin, monotonous voice scarcely audible half-way back in the hall, the editor's neighbor came out of his trance and growled again.

"Say, don't this guy know there's an audience here?" he rumbled. "He hasn't looked up from his manuscript once. And why don't he speak louder? Wouldn't you think some of these guys would take the trouble to ask the men in the back seats if they could hear all right? Then we could hear, too. But the worst thing is reading the paper! He's supposed to be a specialist on turbines, isn't he? Then why don't he at least act like an authority? At least he could memorize the blasted thing and talk as if he knew all about it."

"Uh-huh!" returned the editor sleepily, gradually waking from his doze to discover that the text of the speaker's paper contained some good material, the effect of which was utterly spoiled by his poor delivery.

"By the way," the editor went on, "did you know that the A. S. M. E. had a professional public speaking coach help some of the speakers before the last annual meeting? I hear he made great improvements in the delivery of some of the papers."

"Say, that's a good idea," responded the thick-set man, waking up a little. By this time, the audience was restless and was beginning to talk and shuffle feet. But the speaker, his eyes glued to his manuscript, droned on oblivious of this.

"Yes," continued the editor's neighbor," that's a good idea. It's too bad every engineer can't have some training in public speaking. The public compares engineers with other professional men like doctors, lawyers, architects and you know what a blamed poor showing the average engineer makes in speaking when compared with the others." The editor nodded his agreement.

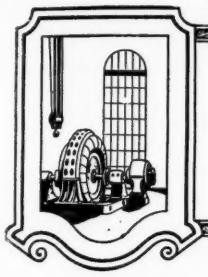
"And another thing—" the thick-set man rumbled. "Why can't copies of these papers be sent out for examination by members before they are delivered, so we can prepare some discussion of them? Why, that's the most valuable part of the whole thing! Then the speaker could just give a short abstract of his paper and then proceed to the discussions. There's hardly a case in which the author couldn't have his paper in the hands of the society two weeks before delivery. Of course, some speakers are afraid of discussion. And then, lots of 'em have their vanity tickled by standing up there and making believe they are delivering a speech when all they do is put the gang to sleep. Bah! What a waste of time! What do we get out of it? We'd be better off to sit around and smoke and just visit with the boys."

"Well, why don't you make your kick to the program committee?" suggested the editor.

"By golly, that's just what I'll do!" ejaculated the thick-set man, knocking the ash out of his pipe and gathering up his coat and hat, as the lecturer finally reached "In conclusion." "I'll do that and I'll tell 'em just what I think of these speakers that mumble into a manuscript instead of addressing the audience. They ought not to be allowed on the platform! Oh, I know it won't do any good"—as he noted the editor's derisive grin—"but at least I'll get it off my chest. Boy, I sure will tell 'em!"

Here the lecturer turned the last page of his MS. and the chairman asked if there was any discussion. As those of the audience who had not walked out had remained only in a state of suspended animation, there was naturally no discussion.

CONTRACT has been signed by The United Gas Improvement Co. and the Erie County (Pa.) Electric Co., under which U. G. I. will act as consultant and assist in the management of the Erie company, according to an announcement made recently by Arthur W. Thompson, president of The U. G. I. Co. "We consider it a compliment to our organization," Mr. Thompson said, "that the Erie County Electric Co., in which U. G. I. has no financial interest, should seek our help."



ELECTRICAL MACHINERY FOR LIGHT AND POWER

The Reactive Component in A. C. Circuits

PART III. THE GENERAL PRINCIPLES GOVERNING POWER FACTOR IMPROVEMENT. BY V. E. JOHNSON

POWER FACTOR in electrical apparatus is not a thing that can be easily controlled like voltage or load. The power factor characteristics of electrical apparatus are determined by its design and the magnitude of the wattless component cannot, except in special cases, be controlled. Power factor improvement is therefore largely a matter of economically generating and distributing the necessary reactive current.

Take, for example, the simple case of a 100-hp. motor having a reactive component of, say, 40 kv.a. at full load. The ordinary source of this wattless current would be the supply generator, and if the line losses are inconsiderable and the equipment capacity ample, this would be economically and electrically satisfactory and sound.

On the other hand, if the existing load conditions are such that the addition of this motor will necessitate the installation or operation of an additional unit, or if the feeder capacity is limited, it might be more economical to supply the 40-kv.a. reactive component from a source other than the generator. It would ordinarily be desirable to locate this external source near the motor in order to reduce transmission losses.

GENERAL PRINCIPLES OF POWER FACTOR CORRECTION

In general, the example of the single motor above illustrates the procedure that must be followed in improving the power factor conditions. There are essentially only two basic courses open—either the demand for wattless current must be reduced by changing the nature or the operating conditions of the utilization apparatus, or else corrective equipment must be installed.

It must, however, not be assumed that wattless current can in all cases be most economically supplied from external sources, for after all, the greater portion of it is now and perhaps always will be supplied from the generating units. It is evident that from the standpoint of the generating unit itself, an economy of material results from the simultaneous generation of reactive and power components in the same windings. Under this condition the total current is the vector sum of the components.

If, on the other hand, the reactive current is generated in one unit, while another, operating at unity power factor, is used for the power component, the total current capacity must be equal to the arithmetical sum.

Example: Assume a load of 100 kv.a. at 70.7 per cent power factor. The power and reactive components will be 70.7 kw. and 70.7 kv.a., respectively. If one generator supplied these simultaneously, its capacity would need to be 100 kv.a. If they were generated in separate machines, each would need to be 70.7 kv.a., making a total of 141 kv.a. This power factor is the limiting condition.

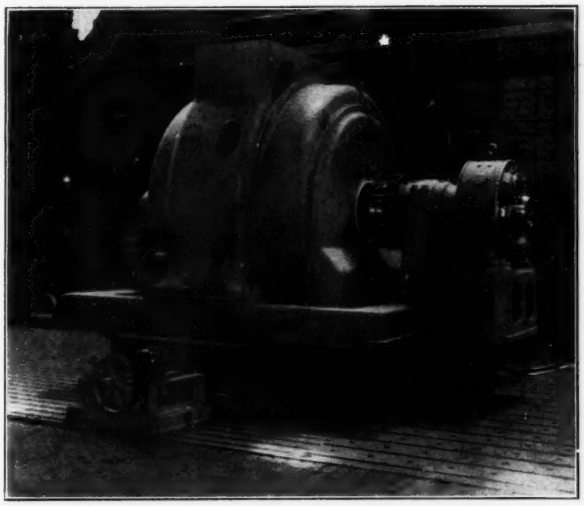


FIG. 1. A LARGE SYNCHRONOUS CONDENSER FOR POWER FACTOR CORRECTION ON TEST AT THE FACTORY

The economy of rating so effected would be offset in varying amounts by the design characteristic of the generators, which would determine the amount of excitation required under the two operating conditions. It should also be noted that at other power factors, either higher or lower, the required excess capacity becomes less, approaching zero as they approach unity or zero.

If the power factor is no lower than that for which a station is designed, there is no wasted prime mover or boiler capacity. If it is higher, there is a waste of generator capacity due to the inability of the prime mover to handle the increased power output. Maximum utilization would come at the rated load conditions, at which operating point the investment per kilowatt output would be at a minimum.

It has become almost universal practice to rate generating units at 80 per cent power factor, and standardization on this point has reduced manufacturing

costs. Under conditions where some other rating appears to be desirable, the final decision should take into consideration the added cost of special designs.

Although supplying wattless current from the generators may, under certain conditions, be the cheapest from the standpoint of production cost at the machine terminals, this is seldom the determining feature. The real basis on which an analysis should be made is that of cost at the point of utilization, namely, the motor terminals. This would include all of the various items of transformation and transmission losses and charges which are affected by the amount of current flow, and by the phase relations in the circuit.

Inasmuch as low power factor increases the voltage regulation, it may somewhat affect the quantity or quality of the output of electrically driven machinery. Therefore, theoretically, the cost of energy should be based on the unit of product output rather than on the kilowatt; this may, however, be very difficult to measure accurately and fairly.

FIG. 2. A GROUP OF STATIC CONDENSERS FOR POWER FACTOR CORRECTION

Making a Survey

Primarily, a careful survey of the existing conditions must be made, with a view to obtaining information somewhat as suggested by the following outline:

1. The present power factor conditions, with particular reference to the total cost of the wattless current used. This cost analysis should take into consideration the value of reclaimed equipment capacity, the effect of power factor penalty clauses (where power is purchased), the additional income netted from the operation of such power factor clauses (where power is sold subject to them), the cost of additional losses chargeable to the wattless component and the consequential losses due to impairment of service.

2. The cause of the undesirable power factor conditions. This requires a detailed study of existing and proposed motor and other applications. Changes in existing installations should be noted, but approached with caution. The selection of new equipment should be made with reference to all of the conditions to be met.

3. The cost of improving power factor by means of a rearrangement of the present equipment should be estimated as closely as possible. This should be balanced against the cost of the wattless current as determined in paragraph 1 above. The power factor after the change can be pre-calculated by using the apparatus performance data in connection with duty cycles determined by the nature of the load. Particular attention should be paid to the reduction of peak loads. Under this general heading would come the reduction of idle connected horsepower by substitution of smaller motors, or grouping them to permit the use of larger units.

4. The cost of substituting other types of motors for those at present installed should be carefully investigated. Synchronous and compensated induction motors may be used to advantage on many applications, the cost and operating features being balanced against the cost of group correction to be considered later.

5. The cost of power factor improvement by providing separate sources of wattless current, such as static condensers and synchronous phase modifiers should be compared with the expense and saving under paragraphs 3 and 4 above. It should be borne in mind that it is usually cheaper to install synchronous motors in connection with a mechanical load, particularly if the corrective kv.a. required is not excessive.

6. The survey so made should be used as a basis for determining:

A. Whether the power factor needs correcting.

B. How it can best be corrected, and to what extent.

C. Whether the cost is justified.

Correction by Re-arrangement or Changing of Motors

From the standpoint of power factor, overmotoring a drive is undesirable, due to the proportionately high wattless current. It should, however, be borne in mind that the running horsepower of a load is not always the determining factor, and that frequently excess capacity is required by other operating conditions, such as high starting duty, intermittent peaks, or high ambient temperature.

Examples:

A. A conveyor which, due to the nature of the material handled, sometimes "sticks", may require high ratings for short periods.

B. Apparatus with intermittent characteristics must be motored to carry the peak.

C. Motors installed in very dirty places require liberal ratings.

D. Special operating hazards such as sometimes met in textile mills and the like, may require large excess ratings.

If there are no limitations similar to the above, each motor should be considered with reference to the pos-

sibility of a reduction in size, or increase in speed. This can often be accomplished without the purchase of additional equipment, by merely re-arranging the existing installation. The use of synchronous motor drives or compensated induction motors will reduce the wattless component, but may be impractical from other standpoints. The latter type has a corrective factor arbitrarily fixed by the design and ordinarily not easily adjusted, thus necessitating an appropriate balancing of operating capacities between them and the non-compensated apparatus.

A number of practical considerations may make any motor change undesirable or uneconomical. The expense would usually be high, as it would necessarily include any loss due to the interruption of production during the period of change-over. Increased maintenance costs and the possibility of decreased reliability from the use of more complicated motors would also be a charge against the new installation. With "built-in" motors, the procedure would be out of the question.

On the other hand, loads of fairly large size, that run continuously without excessive peaks are well adapted to synchronous motor drive. Starting duty beyond the torque of an ordinary motor may, if the application is otherwise desirable, be provided for by means of special clutches and similar unloading devices.

Correction by External Sources of Wattless Current

If the survey and motor study indicate that it is uneconomical, impractical, or otherwise undesirable to change the sizes or types of the existing motors, and if no proposed additional load presents any features that may employ to advantage synchronous or compensated motors in sufficient ratings to improve the power factor conditions, recourse must be had to separate sources of wattless current.

The simplest and most direct method of supplying the wattless component is by providing excess generator capacity. Under many conditions this may be objectionable because it necessitates an unbalance between prime-mover and alternator ratings, and because it compels the out-of-phase current to flow through an unnecessary length of conductor. Under some conditions it is possible to utilize the generator end of stand-by equipment as a synchronous condenser; this requires special precautions to prevent damage to the prime mover. Furthermore, if the load is such as to require the use of "stand-by" for everyday service (even as corrective equipment), there is evidently very little spare capacity to fall back on in the case of an emergency.

The synchronous motor was the first type of machine to be used as a phase modifier, and is still supreme in this field. There is some disadvantage due to the high first cost in the smaller sizes, the need of direct current excitation, the noise and vibration, and to the necessity of at least some attendance. On the other hand, it is reliable and efficient, and provides a means for readily adjusting the amount of correction.

Static condensers are a comparatively new application of an old and well known principle. They are built for various voltages from 220 up to 5000 and in capacities up to about 300 kv.a. The corrective effect is fixed and cannot be changed without disconnecting some of the component units, so that adjustment can at best be made only in a few fairly large steps. On the other hand, the cost for the available ratings is low as compared to a synchronous machine, there is no noise or vibration, foundations need be designed to carry only the dead weight and no attendance is necessary. If the service is interrupted, the restoration of power automatically puts it back on the line. It is available for outdoor service and can, therefore, be applied in a great many places where a synchronous phase modifier would be out of the question.

The following tabulation gives a rough comparison to serve as a guide in choosing between the two:

	Static Condenser	Synchronous Phase Modifier
Cost	Lower up to about 300 k.va.	Lower above about 300.
Installation	Very simple.	Must be lined up and leveled.
Foundation	Sufficient for dead weight only.	Must suffice for a rotating machine.
Noise and Vibration	None.	Depends on size and speed.
Location	Anywhere, indoor or outdoor in residence section.	Not desirable where noise and vibration are objectionable.
Adjustment	Cannot be adjusted. For lagging PF only.	Capable of automatic or manual adjustment to maintain either constant PF or constant voltage under either leading or lagging current conditions.
Efficiency	Very high.*	Not so high.
Control Apparatus	Very little required.	Considerable required. However, this permits flexible operation.
Attendance	Limited. Is self-starting after an interruption.	Some required for oiling, adjustment and re-starting after an interruption.
Life	Very long.	Very long.
Localized Application	The cost of a static condenser is proportional to the rating, so that it is possible without excessive cost to split the corrective capacity up into small units located near the apparatus requiring magnetizing current.	The cost for small units is high so that correction is limited to the bus or to groups.

*Cost of power per kw. must therefore be considered, a high rate favoring the static condenser.

Static condensers, or capacitors, may be applied to individual motors, in which case the corrective kilovolt-amperes are supplied directly at the utilization point, thus eliminating all transmission loss. A fixed capacity applied to an induction motor under variable load will result in a variable resultant power factor, but will hold it within comparatively narrow limits. This is due to the fact that the reactive component of an induction motor changes only about one-tenth as much as the horsepower output, increasing on a 25-hp. motor only about 9 per cent, while the load grows from 50 per cent to 100 per cent rating.

The following tabulation is based on performance data covering a few ratings in common use, and indicates the results that are obtained with fixed corrective capacity and varying load. The motors are of the squirrel cage type, and rated at 220 v., 60 cycles, 3 phase.

		Half load reactive	Full load reactive	Condenser capacity	Resultant power factor Half load	Resultant power factor Full load
Hp.	R.p.m.	kv.a.	kv.a.	kv.a.	%	%
5	1760	2.03	2.45	2	100	100
10	1760	2.32	3.90	2	99	98
25	1160	7.35	8.10	6	99	99
50	870	19.4	23.2	10	91	95
100	870	32.0	39.8	20	96	97

On the other hand, group correction will not be accurate when the reactive component is varied, due to the intermittent operation of the individual motors, unless the number of active units in the capacitor be changed.

Correction by the Addition of Loads with High Power Factor

Aside from the preceding methods of improving the power factor conditions, it is possible to decrease the angular displacement by adding loads with inherently small reactive components. This solution cannot always be used in correcting the conditions existing in industrial plants, but if the manufacturing process permits the use of electrical heat, it may be possible to substitute this for gas or other fuel and so reap double benefits in the form of better power factor and more satisfactory process work.

Central stations are in a more favorable position in obtaining improvement by this method. Domestic and commercial cooking appliances operate at almost unity power factor and their use should be encouraged. For similar reasons, the various types of industrial heaters form exceedingly desirable loads. Furthermore, this type of load is in itself profitable, so that the resultant correction is really a by-product that accrues to the utility without cost.

Apparatus for Transmission Systems*

Development of the Klydonograph and the Du Four Oscillograph Great Factors in Transmission Line Research. By A. C. Monteith†

THE MUCH discussed question of stability is just another way of considering continuity of service. It is recognized that a limited amount of power can be transmitted over a given line without loss of synchronism. In order to keep the fixed charges per kilowatt a minimum, as much power is transmitted per circuit as possible. The nearer the line is operated to its limit the greater will be the probability of outage in case of a disturbance. The question naturally follows, how close can the line be worked to this limit and give reasonable service? The interruption placed on reasonable service will be a large factor in the answer.

The general principles to be considered in the layout of a system to insure good service are briefly as follows:

1. Use of low series reactance.
2. Maintenance of machine voltage.
3. Protection against surges.
4. Rapid and selective isolation of faults.
5. Layout of systems to limit short circuits.
6. Supply of reactive power as close as possible to the point in which the demand originates.

Very little can be done in the transmission line itself to decrease the series reactance but during the last year or more in certain cases the use of lower leakage reactance in machines has been found economical.

The maintenance of machine voltage or more accurately the air gap flux in synchronous machines may be accomplished in two ways, either by the use of low synchronous reactance or by the use of quick response excitation system. The latter is very much less expensive.

Protection Against Surges

Surges on transmission lines may be caused by lightning or switching operations. Lightning is one of the worst sources of trouble. In the last 2 or 3 yr. rapid progress has been made in acquiring reliable information on lightning phenomena.

There are three predominating questions when considering lightning protection; first, the nature and magnitude of the voltages which give rise to the need for protection; second, the way these voltages are affected by protective devices and third, the effect of such voltages, as they originate and as they are modified by protective devices on apparatus installation. All of these phases of the problem have been uncertain largely owing to the great difficulty of measurement of phenomena occurring in such extremely brief intervals of time. The study of the actual voltages on lines introduced by lightning is doubly difficult because of the fact that these voltages may appear at any instant and that the interval between occurrences is millions of times as long as the actual duration of the voltage.

The development and introduction of the klydonograph by J. F. Peters, in 1923, gave renewed impetus to the study of these voltages. This device made possible for the first time the measurement of lightning voltages with a reasonable degree of accuracy. The characteristic which makes this device of particular value for such work is that, although it will operate for a week or more without attention, it will record the magnitude of voltages which last for only a fraction of a millionth of a second.

It is evident that increased knowledge of the magnitude of voltages introduced by lightning can do relatively little to improve the conditions in general without a knowledge of the way protective devices act under the influence of such voltages. K. B. McEachron introduced into lightning arrester research the DuFour Cathode Ray oscillograph, developed by Alexander DuFour in France during the period from 1914 to 1920. This instrument makes possible laboratory studies of the performance of protective devices with as much certainty and precision as can be obtained with the well-known vibrator type of oscillograph. Voltages and currents with a total duration of only a few micro-seconds can be completely pictured with assurance.

The increasing realization of the importance of eliminating line insulator flashovers and the indications by klydonograph studies that merely increasing line insulation is unlikely to accomplish this result, has led to consideration of preventing these flashovers by protective devices.

Some study has been made of the possibility of reducing flashovers by the use of lightning arresters distributed along the circuit and it is felt that this has considerable promise. Relatively small and inexpensive arresters will serve, provided they have characteristics making them faster in operation than the insulators

*Abstract of a paper presented at the Midwest Power Conference.

†General Engineer, Westinghouse Electric & Mfg. Co.

being protected. The permissible spacing between arresters for complete elimination of flashovers depends on the relative time of operation of the arrester and flashover of the insulator at any particular voltage.

The advantage of rapid and selective isolation of faults on transmission systems from the service viewpoint is recognized. Careful study of the performance of systems has indicated that considerable improvement in service can be obtained by proper relaying. The oil circuit breakers must also be of ample capacity to clear the fault.

There have been few changes in the past year in the relaying as applied to the ordinary system, and a very complete line of relays, which have proven themselves, is available.

The interconnection of large power systems requires special treatment to give a relay scheme that will secure proper sectionalization for the present system but allow future revisions and extensions. The main difficulty in the relaying of these interconnected systems is the fact that it is possible under some conditions of operation to get fault currents less than maximum load currents under other conditions.

Pilot wire schemes of protection are used and approach the ideal, but the difficulty of installing and maintaining the pilot wires prevents their use on all but the shortest lines. For back-up relay protection additional relays are required.

Some attention has been given to the use of superimposed high frequency potentials and currents on the transmission lines in the past year. The advantage of this scheme over the pilot wire scheme lies in the fact that no additional wires are required.

One scheme uses high frequency current produced by separate equipment at each end of the section of the line. The equipment is connected to the transmission line through current transformers in such a way that the emission of impulses is controlled by the direction and amount of line current. Reception of the impulses at the other end of the line is controlled by current transformers and the complete arrangement is such that the radio relays will permit the breakers at each end of the line to be tripped whenever the power current flows into the section from both ends. The actual tripping is done by overcurrent or directional relay of the conventional type.

Another scheme makes use of a lower frequency of say 500 to 2000 cycles. The super-imposed high frequency potential is generated by small 3 phase generators situated at various points on the system. The frequency used is high enough that very little current will leak through the power apparatus because of its high impedance to high frequencies. When a fault occurs, the nearest high frequency generator causes a heavy current to flow and operate relays at each end of the faulty line.

Both of these schemes have features which appeal to the protection engineer but they are still in a more or less experimental state.

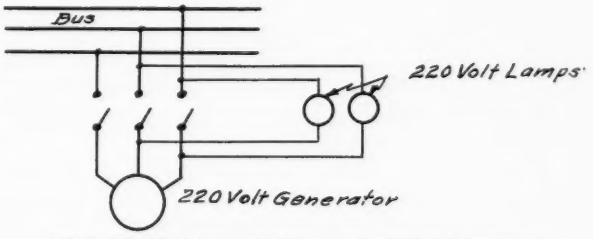
There has been no fundamental change in the method of circuit interruption. Companies engaged in the manufacture of circuit interrupting devices are spending considerable money investigating all leads that might result in a device for opening power circuits other than by an oil circuit breaker. The oil circuit breaker, however, remains the universal commercial switching device.

Attention should be given to the system layout and the supply of reactive power on large interconnections. Miniature systems have been operated for steady loads and under transient conditions. This method has worked out particularly well to show the improvements possible by means of intermediate condensers on long transmission lines. Another form of miniature system has been found exceedingly useful, that is, the mechanical analogy for representing performance of power systems. During the past year the mechanical model developed by Mr. Griscom has been utilized for illustrating the fundamental factors entering into the transmission problem. More recently the model has been adapted for the solution of complex systems.

Considerable test work has been done on actual systems in the past few years both with staged tests and chance tests. There are several instruments available for this class of work. The Hall recorder has been installed on systems to measure current and voltage during transient conditions. Automatic oscillograph instruments have also been developed and used for measuring voltage, current, power, reactive power and mechanical movements all of which are recorded on a film usually of the daylight loading type. This oscillograph apparatus can be placed in operation automatically by the use of suitable initiating relays.

Procedure in Starting Up a New Generator

A. L. COOPER of the Holly Sugar Corporation, Swink, Colo., has directed our attention to an error in the article under the above title on page 253 of the Feb. 15 issue.



FULL BRILLIANCY METHOD OF SYNCHRONIZING

This error is in the diagram, Fig. 2. The lamp connections, instead of being as shown, should be reversed as in the accompanying diagram. This error is not the author's but occurred in redrawing the original sketch.

CODES FOR the prevention of dust explosions in terminal grain elevators and flour and feed mills have just been adopted as American Standards by the American Engineering Standards Committee. Preparation of the codes was sponsored by the United States Department of Agriculture and the National Fire Protection Association, working with a Sectional Committee of the A. E. S. C. Standards were recently adopted also for pulverized fuel systems, starch factories and pulverizing systems for sugar and cocoa. Others are being studied at the present time for sulphur crushing and pulverizing, spice grinding and pulverizing, wood working and pulverization and atomization of metals.

Typical Installations of Unit Heaters

DESCRIPTION OF TYPICAL INSTALLATIONS OF UNIT HEATERS IN INDUSTRIAL BUILDINGS, CALCULATION OF HEAT LOSSES AND SELECTION OF EQUIPMENT

INDUSTRIAL plant engineers are becoming more and more interested in the subject of unit heaters for all sorts of heating applications. It is the purpose of this article to discuss briefly some of the factors entering into the problem of selecting the proper unit heaters and locating them in the industrial buildings so that they will give the most comfort to the occupants at the lowest cost.

As every engineer knows, a unit heater consists of a heating element of some sort, usually heated by steam, through which air is drawn or blown by a fan. The object of the arrangement, of course, is to increase the radiation of the heating surface and at the same time to direct the heated air in such a way as to produce air circulation with effective heating. While a radiator gives off about 240 B.t.u. per sq. ft. per hr., the average unit heater will give off about 1500 B.t.u. per sq. ft. per hr. with 5 lb. steam pressure and 60 deg. room temperature.

Unit heaters are used sometimes for drying in industrial processes and for similar applications. Then there are the recently developed types for office building and domestic use. Some of these employ fans while, in others, air is drawn through the heating element by natural circulation. Discussion of these types of heaters is beyond the scope of this article.

HEATERS FOR INDUSTRIAL BUILDINGS

Two general types of heaters, the floor type and the ceiling or suspended type, are used for heating industrial buildings. There seems to be considerable difference of opinion among manufacturers of this equipment and also among heating engineers as to which is the better type to use. Many installations of each type have been in successful operation for long periods. The engineer must be guided, therefore, by considerations peculiar to his own plant conditions.

The problem is further complicated by the fact that there are many variables and no two sets of heating conditions are exactly alike. Manifestly this is so because of the great difference in area, in height, in exposure and construction of the industrial buildings as they are met today. There are, however, several principles that, with modifications, will guide one aright in nearly every case.

Before a heating engineer can determine at what point he will locate a unit heater, he must study the building; he must consider the floor area, the height of the building, its exposure and its use (manufacturing process to be carried on therein) and its heat losses. He must determine whether air is to be recirculated, taking no outside air, other than infiltration, or whether all air is to be taken from outside with no air recirculated, or whether a portion is to be recirculated and a portion taken from out of doors; if so, in what proportions. Next he must determine type of unit that can be used, whether the owner will give valuable floor space along walls or beside columns in center of room, or whether units must be kept off from the floor entirely.

When he has all these data before him, there are some fundamental rules to guide him as follows:

(a) Cold air should always be taken from floor, or if this cannot be done, warm air *must* be distributed on floor.

(b) Warm air should be blown toward exposure so as to blanket it, returning to the unit at floor line. Cold air falling from roof should be stopped by an ascending current of warm air.

(c) Warmed air cannot be successfully blown across high section of buildings to heat exposure on far side.

(d) If heating unit is to be of the suspended type, discharging directly to the zone in which it rests, cold air from floor must be conducted to it, if heating is to be accomplished with the minimum of heating surface, minimum of power consumption and minimum of steam.

ARRANGEMENT OF HEATERS FOR MONITOR TYPE BUILDING

Let us consider a one-story monitor type of building, a building having the maximum of glass in walls and monitor and of large floor area. All air is to be recir-

FIG. 1. INSTALLATION OF UNIT HEATERS IN PLANT OF WELDING COMPANY

FIG. 2. METHOD OF LOCATING HEATERS IN LOCOMOTIVE SHOP WITH HIGH CENTRAL SECTION

culated and units are to be of the floor type. For such a building there are two reasonable locations for unit heaters and we shall name them in their order of importance.

Locate floor type units along the columns on each side of the crane-way, both units discharging two ways; first, toward the exposed wall; second, into the high section. The amount to be discharged toward the exposed walls to be sufficient to compensate for the heat loss through walls, glass, floor and roof up to an imaginary line extending across the crane-way space at the bottom of the monitor. That portion blown into the high section to be sufficient to care for the space within the monitor, roof, glass and walls.

The second choice is to place these units along the exposed wall, blanketing the walls and being of sufficient capacity to heat that portion of the building, walls, glass, floor and roof, embraced within said imaginary line directly under the monitor.

To care for the space within the monitor and to counteract the down currents of cold air, there would be placed on the columns suspended type heaters. These heaters would be of sufficient capacity to care for the space within the monitor and to care for the glass, wall and roof surface therein.

Figure 1 shows a building practically all glass with an area of 177 ft. by 122 ft. and a saw-tooth roof. Here the engineers located the unit heaters along the columns, blowing toward the exposed walls, locating units on both sides of the high section, and blowing into the high section only air enough to care for it. The balance is discharged towards the exposed walls. This building was built in 1924, and has, therefore, gone through four heating seasons successfully.

Heating a Locomotive Shop

The locomotive shop, Fig. 2, is a typical illustration of a large building with high central sections heated with unit heaters. Units are placed on the wall on one side of the building, blowing down and fresh air supply is brought up from the floor line. Units are placed on the balcony, blowing down and drawing air from the floor. This installation has been in successful operation several years. This is a large building, 538 ft. by 180 ft., containing a total of 3,422,000 cu. ft.

Figure 3, taken in an eastern silk mill, shows another installation of unit heaters. This is a one-story building with 8-in. brick wall construction saw-tooth roof, 2 in. tongue and groove plank, covered with tar and gravel. Approximately 50 per cent of the exposed surface of this building is glass. The building is 140 ft. by 150 ft., 14 ft. to the top of walls and 20 ft. to the peak of the sawtooth. The floor is concrete on ground.

FIG. 3. HEATERS IN SILK MILL ARE INDIVIDUALLY CONTROLLED BY THERMOSTATS

This building is heated with 15 unit heaters individually controlled by Mercoid thermostats. The specifications for heating this building read as follows: 75 deg. must be maintained 24 hr. a day, seven days a week, figuring an outside temperature of minus 20 deg. This temperature must not vary more than 2 deg. plus or minus from 75 deg. at any time. The heating system is being operated on a pressure of 5 to 7 lb. with 6 in. vacuum on the return lines. The chief engineer of this plant has stated that these units have saved a great deal of money, since before using them they lost considerable time during cold weather, because the needles of the machines would not function when the temperature of the room dropped below 74 or 75 deg. On cold mornings, operators would stand around for an hour or two waiting for the machines to warm up.

Calculation of Heat Requirements

Following is the detailed method by which the heat loss was calculated for a building to be heated by unit heaters. Figure 4 shows the general plan and cross-

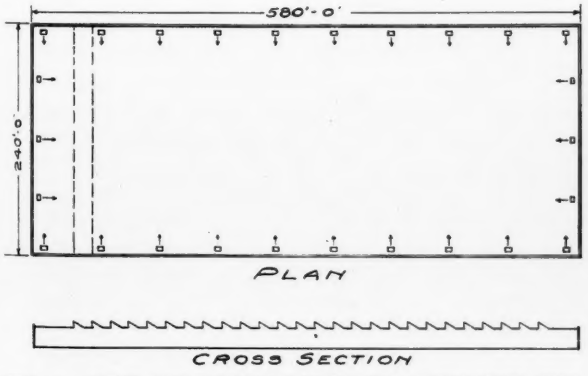


FIG. 4. PLAN AND CROSS-SECTION OF A BUILDING FOR WHICH HEATER CALCULATIONS ARE GIVEN IN THE TEXT

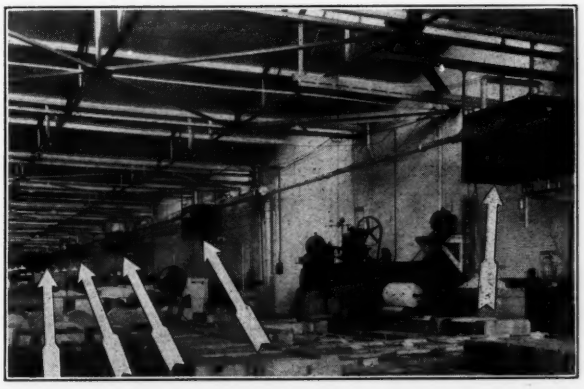


FIG. 5. UNIT HEATERS IN THE BUILDING SHOWN IN FIG. 4, A LARGE PAPER MILL

FIG. 6. LOW CEILING TYPE UNIT HEATERS IN A FURNITURE FACTORY

section of the building and Fig. 5 shows the completed installation.

In figuring the heat losses in this plant, the following information was required: 1, room temperature to be maintained with average minimum outside temperature (See Table I); 2, steam pressure available; 3, square foot area of walls, windows, doors, floor and roof, or ceiling; 4, cubical contents of building; 5, air exhausted for ventilating purposes; 6, air infiltration.

Heat must be supplied to offset the transmission or losses through various types or grades of material and the B.t.u. losses per square foot, per degree of temperature of standard materials are given in Table II.

Temperature of 65 deg. F. was to be maintained with outside minus 10 deg. F., 75 deg. difference. Steam pressure was 5 lb. gage. One B.t.u. is the amount of heat required to raise 55 cubic feet of air 1 deg. F. at 70 deg., or approximately 0.02 B.t.u., to raise 1 cubic foot of air 1 deg. F.

FIG. 7. FLOOR TYPE UNIT HEATERS IN A STEEL MILL

TABLE I. INSIDE TEMPERATURES USED TO DETERMINE HEAT LOSS IN FIGS. 4 AND 5

	Deg. F.
Foundries, etc.	50
Machine shops	65
Factories	65
Public buildings	70
Schools	70
Paint shops	80

TABLE II. HEAT TRANSMISSION CONSTANTS FOR VARIOUS MATERIALS IN B.T.U. PER SQ. FT. PER HR. PER DEG. TEMPERATURE DIFFERENCE

BRICK WALLS

	Plain	Furred and Plastered
8½" thick	0.37	0.28
13" thick	0.29	0.24
17½" thick	0.25	0.21
22" thick	0.22	0.19
26½" thick	0.19	0.16

HOLLOW TILE WALLS

	One Side Plastered	One Side 4" Brick
4" thick	0.64	0.30
6" thick	0.57	0.27
8" thick	0.40	0.23
10" thick	0.35	0.18
12" thick	0.26	0.13

CONCRETE WALLS

	Plain	Furred and Plastered
4" thick	1.00	0.63
6" thick	0.86	0.57
8" thick	0.71	0.47
10" thick	0.65	0.43
12" thick	0.57	0.40
16" thick	0.50	0.33

WINDOWS

Single Glass..1.09 Double Glass..0.46

SKYLIGHTS

Single Glass..1.16 Double Glass..0.48

FLOORS
Laid on Ground

Cement, no flooring	0.31
Cement, wood floor over	0.10
Dirt, no flooring	0.20
Wood, laid on ground	0.15

FLOORS
With Air Space below
Assume temperature Air Space 35°F above outside temperature.

Wood, single plastered under	0.26
Wood, single, not plastered under	0.45
Wood, double plastered under	0.18
Wood, double, not plastered under	0.31

Concrete—See Walls.
Deduct 50% for wood floor covering.

ROOFS

2" Wood, Paper, Tar and Gravel	0.26
Wood shingles on sheathing	0.43
Asbestos shingles on sheathing	0.32
Shingles, paper, sheathing	0.21
4" Hollow tile, paper, tar, gravel	0.30
6" Hollow tile, paper, tar, gravel	0.27
2" Concrete, paper, tar, gravel	0.71
3" Concrete, paper, tar, gravel	0.64
4" Concrete, paper, tar, gravel	0.53
Corrugated iron on strips	1.50
Corrupated iron on sheathing	0.64
Sheet iron	1.20
Sheet iron on sheathing	0.60

For this building, 26 unit heaters of approximately 700,000 B.t.u. capacity each were selected with a high velocity discharge, drawing the air over the heating coils at a low velocity and fan motors of ⅞ hp. for each unit were used.

Heat losses were as follows:

Material	Sq. ft.		Temp. Diff.		B.t.u. loss per hr. per sq. ft. per deg.		Total per hr.
Walls—7½ in. brick	83,420	×	75 deg.	×	0.25	=	1,560,000
Windows—single glass	9,380	×	75 deg.	×	1.09	=	767,000
Doors	1,230	×	75 deg.	×	0.33	=	30,500
Roof—tar and gravel on 2-in. planks	143,680	×	75 deg.	×	0.26	=	2,600,000
Skylight—double glass	37,440	×	75 deg.	×	0.48	=	1,350,000
Floor—wood on concrete	139,200	×	25 deg.	×	0.10	=	334,000

Note.—The minimum ground temperature is figured at 40 deg. F. regardless of lower outside temperatures.

Air infiltration—Once every two hours.

580 ft. × 240 ft. × 22 ft. = 3,062,400 cu. ft., contents, divided by 2 × 0.02 × 75 deg. = 2,300,000.

Air changes per hour:

3,062,400 × 2 × 0.02 × 75 deg. = 9,200,000

Total B.t.u. loss per hr. = 18,141,500.

Heat produced by electric lights, motors and so on is disregarded.

Figure 6 shows a furniture factory heated by six low ceiling type heaters. Floor type unit heaters, as installed in a large steel mill, are shown in Fig. 7.

In presenting the foregoing data, we have aimed to give some idea of what has actually been done with unit heaters in existing installations. We recognize that the discussion does not by any means cover the subject. Questions of proper velocities of air to use through the heaters, horizontal spacing of heaters, and other phases of the problem are somewhat controversial at this time and various manufacturers have various designs to fit the conditions encountered.

Rebabbiting Bearings

STATEMENT OF PRACTICAL CONSIDERATIONS NECESSARY TO SECURE SUCCESS IN BABBITING

SUCCESS IN BABBITING depends upon the composition of the metal, upon the treatment given to the parts into which the babbit is to be poured and upon the method of pouring. Inquiries that have been made regarding white metals for bearings indicate a need for practical information on these features of the subject.

TABLE OF PHYSICAL CHARACTERISTICS OF DIFFERENT COMPOSITIONS OF WHITE BEARING METALS

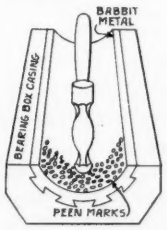
Alloy	Composition, Per cent					Brinell Hardness		Temperature, Deg. F.	
	Tin	Antimony	Lead	Copper	Arsenic	At 70° F.	At 212° F.	Melting	Pouring
1	91	4.5	0.35	4.5	0.10	28.6	12.8	437.0	824
2	89	7.5	0.35	3.5	0.10	28.3	12.7	460.4	808
3	83.3	8.3	0.35	8.3	0.10	34.4	15.7	462.2	916
4	75	12	10	3	0.15	29.6	12.8	365.0	680
5	65	15	18	2	0.15	29.6	11.8	365.0	661
6	20	15	63.5	1.5	0.15	24.3	11.1	365.0	638
7	10	15	75	0.5	0.20	24.1	11.7	464.0	625
8	5	15	80	0.5	0.20	20.9	10.3	469.4	625
9	5	10	85	0.5	0.20	19.5	8.6	469.4	616
10	2	15	83	0.5	0.20	17.0	8.9	473.2	625
11		15	85	0.5	0.25	17.0	9.9	476.8	625
12		10	90	0.5	0.25	14.3	6.4	476.8	634

The essential characteristics to be considered in any alloy for bearings are composition, structure, change of shape in hardening, temperature of running, wear on bearing, wear on journal, compressive strength and cost.

SELECT ALLOY ACCORDING TO SERVICE DEMAND

It is utterly impossible to have one alloy reach the height of perfection in all of the above requirements,

FIG. 1. MANY LIGHT BLOWS OF A BALL-PEEN HAMMER AID IN MAKING BABBIT ADHERE TO BOX



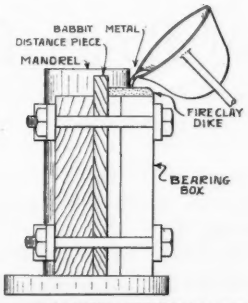


FIG. 2. BABBIT SHOULD BE POURED WITH BOX IN VERTICAL POSITION SO AS TO PREVENT FORMATION OF SHRINKAGE HOLES

so it is important first to determine the purpose for which each is especially adapted. All white metal bearings are made up of at least two structural elements, one hard constituent to support the load and one soft constituent to act as a plastic support for the harder element. Generally speaking, the harder the surfaces in contact, the lower the coefficient of friction and the higher the pressure under which the bearing will grip. It would, therefore, appear that the harder the alloy the better, but a hard, unyielding alloy, for successful operation, must be in perfect alinement and adjustment; a condition which is practically unattainable.

It is generally conceded that soft metal bearings cause a greater decrease in the life of a journal than will some hard metal bearings but their other advantages in many cases more than make up for this disadvantage. When white metals are mixed, the metals to compose the alloy should be melted in the order of their melting points, i.e., the metal having the highest melting point should first be melted then the others in turn added to the melted metal.

Standard babbit metal consists of 80 to 89 per cent of tin, 2 to 10 per cent of copper and 7 to 10 per cent of antimony. The substitution of lead for tin and the omission of copper makes a cheaper and softer metal suitable for low pressures and speeds. The addition of more antimony hardens the metal and causes it to expand in hardening; an action which tends to make the metal adhere closer to the shell into which it is cast.

Variations of this white-metal bearing alloy are shown in accompanying table in which No. 1 is suited

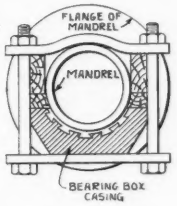


FIG. 3. CLAMPS AND BLOCKING HOLD MANDREL IN PROPER POSITION WHEN BABBIT IS POURED

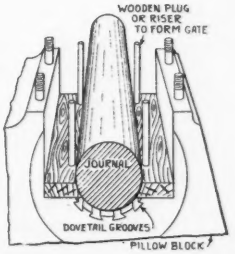


FIG. 4. METHOD OF CLOSING, GATING AND VENTING A BABBIT RECESS IN A PILLOW BLOCK WHEN RE-BABBITING A NON-REMOVABLE BOTTOM SHELL

Note: A bearing so prepared is tamped with molding sand or fire clay. The plugs are set into notches, which notches later form gates for the babbit.

for crankpin service for internal combustion engines. It should be well confined in its backing or used as a thin layer sweated on to bronze or steel. It is least liable to crack and the most plastic. No. 2 has a higher bearing value and is less liable to pound out and is also suitable for being sweated on. No. 3 is the hardest and highest bearing value alloy. It is ideal for the highest service requirements when well seated and impact is not too severe. No. 4 is an excellent alloy for engine main bearings and general machinery. It will withstand severe punishment but high temperatures must be avoided. Nos. 5 and 6 give good bearing service but cannot withstand as high a temperature as a lead base babbit such as No. 7 which is also cheaper. It gives good service and may be used with perfect satisfaction in many places where genuine babbit is now specified. The bearing value of Nos. 8, 9 and 10 decrease with decrease of tin content. Nos. 11 and 12 constitute the cheapest

grades of babbit and should be used only for lightest service.

Only those babbit metals high in tin content and low in lead content can be successfully sweated but other means of holding babbit in its shell work quite as well. Dove-tailed grooves running parallel to the journal should be cast or cut in the box as shown in Fig. 1. The babbit, after being cast, is peened with a ball-peen

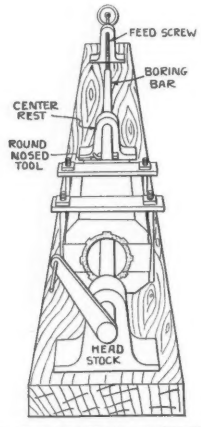


FIG. 5. HANDY JIG MAKES BORING OF BABBITED BEARING BOXES A SIMPLE MATTER

hammer as shown. Many light blows rather than heavy blows should be given, the object being to spread the metal at the surface and therefore cause it to swell and force itself into the grooves rather than to pound it in with the result that it rebounds from the surface with which it is desirable to have it closely adhere.

If the babbit does not adhere closely it will not only be loose and cause trouble but the air spaces will act as a non-conductor and heat created by the journal when running would not be as readily dissipated by radiation. The advantage of using antimony in the babbit and casting in dove-tailed grooves which causes the babbit to expand into those grooves and the employment of the peening process will be apparent. After peening, the bearing must be bored to size. Peening also hardens the surface of the babbit by making it more dense.

Cast Lining in Vertical Position

In rebabbiting a bearing it is best to remove it from the engine, if possible, and warm it to a temperature of about 150 deg. F. This prevents sputtering and blowing of the metal when poured and will facilitate the running of the metal to all parts of the box. The bearing should be cast in a vertical position as shown in Fig. 2 so as to prevent shrinkage holes from forming in the babbit. Shrinkage holes will almost invariably result if a large bearing is poured in a horizontal position. A mandrel should be used that is smaller in diameter than the shaft so as to allow for peening and finish. Figure 3 shows how the mandrel is clamped to the box. If the box cannot be removed from the machine, the best method of casting the babbit is shown in Fig. 4.

An improvised jig for boring babbited bearing boxes is illustrated in Fig. 5.

Flat surfaces such as those of flat crosshead shoes may be babbited in a similar manner. Just as in the case of a journal bearing, the dove-tail grooves should lie across the bearing surface so that when heated in operation there will be less tendency for the babbit to be wiped out of the grooves.

Embrittlement of Boiler Plate*

Causes and Descriptions of Cracks Due to Embrittlement and Methods of Inhibition. By S. W. Parr† and F. G. Straub‡

WITHIN recent years, a phenomenon of more or less frequent occurrence has become recognized, to which the term "the embrittlement of boiler plate" has been applied. Because of the relatively infrequent occurrence of this difficulty and the more or less obscure causes which bring it about, the fact of embrittlement has been largely in question. Both the evidence of its presence and the conditions which promote it, however, are matters of paramount importance at the present time, because within recent years an increased number of boiler failures chargeable to embrittlement have occurred.

Historical development of the study of the phenomenon of embrittlement would undoubtedly show that many cases of boiler failure were laid to other causes than embrittlement in years gone by. The first indication the industry had that this type of failure was different from any previously encountered was in 1895 when a plant at DeKalb, Illinois, encountered cracking in drums which were installed in 1893. At that time the suggestion was made that the feedwater might be the cause, but small attention was given to it. In 1906 one of the authors described an unusual type of water and outlined an area where it occurred, having Champaign-Urbana as a center and extending west as far as Bloomington, Illinois, and east as far as Veedersburg, Indiana.

This water was characterized by having free sodium bicarbonate present and an almost complete absence of sulphate.

During the interval between 1916 and 1924, much investigation was done to explain the cause of embrittlement failures which were continuing to increase. The research conducted by Babcock and Wilcox Co. did much toward explaining the difficulty and bringing the issue before the boiler user. On the other hand, any suggestion that alkaline waters may have been a contributing agent was naturally opposed by water treating companies which produced alkaline water as a result of their treatment.

A detailed description of some 300 cracked boilers from plants encountering difficulty in the form of em-

*Abstract of paper presented at the Midwest Power Conference, published by permission of the Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

†Professor of Applied Chemistry (Retired), University of Illinois, Urbana, Ill.

‡Special Research Assistant, Engineering Experiment Station, University of Illinois, Urbana, Ill.

brittlement was given in the appendix B of Bulletin 155. Only a brief review of the type of cracking will be given here.

1. The cracks occur primarily below the water level.

2. The cracked plates have always been in tension and the cracks occur at points of high localized stresses.

3. Seams having factors of safety as high as 10 have encountered cracking.

4. The cracking is not confined to poor steel but occurs in steel of excellent quality as well as in steel not so good.

5. The cracking has occurred in seams in boilers built as late as 1924, and with seams being as well made as possible then.

6. Both outside calked and outside with inside calked seams have cracked.

The characteristics of these cracks may be summarized as follows:

a. They do not follow the line of what is generally considered the line of maximum stress.

b. They start on the dry side of the plate.

c. They run in general from one rivet hole to another, though they often run past each other, leaving islands of plate.

d. They are irregular in direction.

e. They never extend into the body of the plate beyond the lap of the seam.

f. There is no elongation of the plate.

g. Rivet heads crack off or are easily dislodged.

h. A microexamination of all the cracked plates reveals the fact that the crack progresses around the grain boundaries, intercrystalline.

Water Conditions

A summary of the chemical conditions which characterize the water used in the boilers where embrittlement has occurred is as follows:

(a) Sodium carbonate is the one substance which is invariably present in the feedwater.

(b) Sulphate hardness is usually absent or low in respect to the sodium carbonate present. Sodium sulphate is similarly lower than the sodium carbonate.

(c) Boilers encountering this trouble used waters having characteristics noted under (a) and (b) and as a consequence of the chemical reaction in the boiler, develop a caustic condition with sodium hydroxide in material excess over the sodium sulphate.

In 1926 the American Society of Mechanical Engineers in their Boiler Construction Code called attention to the presence of embrittlement cracking and recommended definite sulphate to carbonate ratios to be maintained as a precautionary measure toward stopping this trouble. They included in this recommendation the following explanatory paragraph:

"Cracks of this particular character have not been reported in cases where water softening equipment has been intelligently used, maintaining close control over boiler concentrations and the boilers have been properly operated."

At the time this code was recommended, this clause may have been warranted; but the data collected since appears to indicate that water treatment carried on as directed by the manufacturers of the equipment has resulted in the embrittlement of boilers. The concentration had been closely watched and the boilers were properly operated.

Causes of Embrittlement

On examining the mass of data collected from embrittled boilers, one could not help seeing that the type of feedwater used in embrittled boilers was apparently the only common factor. When the feedwater was analyzed, it disclosed the fact that sodium carbonate was always present while the sulphates were much lower. The boiler waters showed the presence of a high alkalinity with a corresponding small sulphate content.

Boiler feedwater can be considered roughly under two heads, carbonate or sulphate. The former has the carbonates of magnesium or calcium in excess and has only a small amount of the corresponding sulphates. This has commonly been termed temporary hardness since it decreases on heating. The sulphates of calcium and magnesium are changed but little on heating and have been termed permanent hardness. In some natural waters in the United States, sodium bicarbonate is present in appreciable amounts and almost invariably the sulphates are low in respect to the sodium bicarbonate. On heating the boiler the sodium bicarbonate breaks down to give the carbonate, which, in turn, decomposes to give sodium hydroxide and carbon dioxide.

TABLE I. ANALYSIS IN GRAINS PER U. S. GALLON OF WATER TAKEN FROM BOILERS HAVING HIGH SULPHATE CONTENT. NOT EMBRITTLEMENT

Steam Pressure carried, lb. gage	150	175	175	125
Sodium Hydroxide, NaOH	2	5.8	7.6	36.3
Sodium Carbonate, Na_2CO_3	10	6.1	19.9	8.7
Total Alkalinity as Na_2CO_3	13	14.2	30.5	59.5
Sodium Sulphate, Na_2SO_4	200	42.2	71.5	102.4
$\frac{Na_2SO_4}{\text{Alkalinity as } Na_2CO_3}$	15.4	2.9	2.4	1.7

$$H_2O + Na_2CO_3 = 2NaOH + CO_2$$

Water + sodium carbonate = sodium hydroxide + carbon dioxide.

The amount of decomposition of the carbonate depends upon the temperature or steam pressure and the partial pressure of the carbon dioxide. In a boiler, the steam carries away the carbon dioxide favoring the formation of the hydrate. Boilers have been found where over 90 per cent of the sodium carbonate has gone over to the sodium hydroxide.

One thinks at once—all boilers have sodium hydroxide in them, since soda ash is a common boiler compound. This is so—yet the amounts are no place near those encountered in embrittled boilers and, furthermore, the sulphates are present in large amounts. Table I gives the analyses of boiler waters commonly encountered and shows the high sodium sulphate content.

If calcium or magnesium sulphates are present, soda ash is added to form the less soluble carbonates and sodium sulphate.

$$Na_2CO_3 + CaSO_4 = Na_2SO_4 + CaCO_3$$

Sodium carbonate + calcium sulphate = sodium sulphate + calcium carbonate.

The sodium sulphate is increased so that an excessive amount of soda ash would be necessary to bring about

an excess over the sulphate in normal permanent hardness. A water containing small amounts of sulphates could readily be changed to one in which the soda ash is in excess by soda ash treatment and such types have been found in use in embrittled boilers.

Thus sodium carbonate may be in the feedwater in excess of the sulphate by either one of two causes. First, in a well water having the sodium carbonate present and second, as the result of water treatment. The addition of an excess of soda ash will furnish such a water, or it may result from the use of the zeolite process of softening. This system of softening is accomplished by means of either a mineral or artificial zeolite. The bicarbonates of calcium and magnesium are converted to the bicarbonate of soda and sulphates of calcium and magnesium to sodium sulphate, thus furnishing a water with zero hardness. The zeolite is rejuvenated by treating with sodium chloride solution. This system, when used on a water having a lower sulphate hardness than carbonate hardness, will produce a water in which the carbonate of soda will predominate over the sulphate and resemble the waters used in embrittled boilers.

TABLE II. ANALYSES IN GRAINS PER U. S. GALLON OF FEEDWATERS USED IN EMBRITTLED BOILERS

Steam Pressure Carried lb. gage	200	250	200	30	225	265	60
Sources of Water	Lake	River	Lake	Well	Lake	Lake	River
Treatment	Zeolite	Zeolite	Zeolite	Zeolite		Lime-Soda	Zeolite
Sodium Hydroxide, NaOH	85.4	24.3	216.0	25.6	63.2	99.2	51.2
Sodium Carbonate, Na_2CO_3	69.2	10.5	74.9	25.5	11.3	25.9	12.4
Sodium Sulphate, Na_2SO_4	44.7	36.2	56.6	13.3	14.9	82.6	3.6
Sodium Chloride	27.3	24.4	87.5	33.9	18.7	45.0	
Total Alkalinity as Na_2CO_3	188.0	44.5	36.1	61.1	94.8	164.9	84.1
$\frac{Na_2SO_4}{\text{Alkalinity as } Na_2CO_3}$	0.24	0.81	0.15	0.21	0.15	0.50	0.04
Recommended A.S.M.E. ratio	2.0	3.0	2.0	1.0	2.0	3.0	1.0

TABLE III. ANALYSES IN GRAINS PER U. S. GALLON OF BOILER WATERS FROM EMBRITTLED BOILERS

Steam Pressure Carried lb. gage	200	250	200	30	225	265	225
Sources of Water	Lake	River	Lake	Well	Lake	Lake	Well
Treatment	Zeolite	Zeolite	Zeolite	Zeolite	Zeolite	Lime-Soda	None
Calcium Carbonate	0.15	0.0	0.0	0.0	0.20	0.41	3.16
Magnesium Carbonate	0.10	0.0	0.0	0.0	0.29	0.41	1.98
Sodium Carbonate	9.33	11.47	5.83	18.9	8.90	4.00	9.05
Sodium Sulphate	2.23	10.30	1.63	2.0	1.50	2.10	0.12
Sodium Chloride	1.10	3.18	1.25	1.6	1.50	1.34	10.50
$\frac{\text{Sodium Sulphate}}{\text{Sodium Carbonate}}$	0.23	0.90	0.28	0.10	0.17	0.52	0.01
Recommended A.S.M.E. ratio	2.0	3.0	2.0	1.0	2.0	3.0	3.0

Table II gives the analyses of seven of the waters used in embrittled boilers. This shows the type of water common to every embrittled boiler encountered. The first five represent waters which have been zeolite treated, the sixth soda ash treated and the last a natural sodium carbonate water. These show further that they have not met the A. S. M. E. recommendation. No embrittlement has ever been experienced on waters meeting this code recommendation.

Table III gives the analyses of seven waters taken from the boilers from plants which have encountered embrittlement and illustrates to what extent the hydroxide is formed.

Table IV shows the analyses of waters taken from boilers which have operated on zeolite treated waters and natural sodium waters followed by treatment to meet the sulphate carbonate ratio. No embrittlement has ever been encountered in plants having water like these in the boiler.

Laboratory Investigation

A brief summary of the results obtained from the laboratory tests conducted toward the explanation of this intercrystalline cracking is given below:

(a) Two conditions must be present simultaneously to cause embrittlement of mild steel in the laboratory test containers: first the actual stress must be above the region of the yield point of the metal; and second, the concentration of solution must be above 75 grams per liter (about 4000 grains per gallon).

(b) Solutions of salts occurring in boiler waters other than sodium hydroxide did not affect the stressed metal.

(c) Pure iron cracked as well as regular boiler plate.

(d) Cold work or heat treatment did not accelerate nor retard embrittlement cracking.

(e) Steel subjected to a high intensity of load for 5 years failed to crack; but the same steel under the same load cracked in less than three days when brought in contact with caustic solution.

TABLE IV. ANALYSES IN GRAINS PER U. S. GALLON OF BOILER WATERS TREATED TO INCREASE THE SULPHATE-CARBONATE RATIO

Source of Water	Well	Lake	Lake	Lake	Well
Treatment	Lime and Acid	Zeolite and Acid	Zeolite and Acid	Zeolite and Acid	Lime and Aluminum Sulphate
Sodium Hydroxide NaOH	22	28.2	22.0	36.3	14.1
Sodium Carbonate Na_2CO_3	9	5.3	15.4	14.6	17.0
Sodium Sulphate Na_2SO_4	90	89.8	116.1	119.7	72.8
Total Alkalinity as Na_2CO_3	38	42.7	46.2	55.4	36.6
$\frac{Na_2SO_4}{\text{Alkalinity as } Na_2CO_3}$	2.4	2.1	2.5	3.1	2.1
Recommended A.S.M.E. ratio	2.0	2.0	2.0	3.0	2.0

(f) Increased steam pressure accelerates the cracking.

Inhibiting the Embrittlement

When the attention of the earlier investigators was first called to the fact that sodium hydroxide might be a contributing factor in the embrittling of boilers, attempts were made to stop the formation of the hydroxide in the boiler. The addition of organic matter was tried with no marked success, since it did not retard the decomposition of the carbonate to any extent. Early in 1914, attempts were made at the University of Illinois power plant to lower the sodium carbonate content in the feedwater by adding magnesium sulphate. This formed sodium sulphate and decreased the sodium carbonate content. Later this was changed to a sulphuric acid treatment. The regular line treatment was made and then sufficient sulphuric acid added to neutralize about two-thirds of the sodium carbonate in the water. Before adopting this system of treatment, difficulty had been experienced on all boilers; since adding this treatment, no further difficulty of this nature has been encountered. A recent thorough examination of these boilers, involving removing of rivets and a thorough examination of the rivet holes, showed that after 10 yr.

operation on this treated water the boilers were free from any indications of embrittlement. Within recent years, the tendency toward keeping a definite amount of sodium sulphate in all boilers using sodium carbonate waters has become popular with large power plant operators, so that at present over 20 plants are using this means to inhibit embrittlement. The method of increase of sulphate is accomplished by various means, some using acid while others use aluminum sulphate, iron sulphate, etc. Some plants which encountered embrittlement have changed to other sources of supply free from carbonate, with the elimination of the difficulty.

TABLE V. ANALYSES GRAINS PER U. S. GALLON OF WATER FROM EVAPORATORS USING SODIUM CARBONATE WATER SUPPLY

Calcium Carbonate	0.21	trace
Magnesium Carbonate	0.00	trace
Sodium Carbonate	0.70	0.92
Sodium Sulphate	0.54	0.78
Sodium Chloride	0.34	0.68
Iron and Aluminum Oxides	0.00	trace
Silica	0.12	0.25

Use of sulphate treatment is very limited and since the occurrence of embrittlement is apparently on the increase, other methods of stopping it have been diligently sought. The use of a sulphate ratio on waters low in calcium and magnesium is possible, but when these salts are present it becomes practically impossible to keep the recommended ratios at the higher pressures. Furthermore, the use of acid is only to be recommended when the direct supervision of a man conversant with the use of chemicals is available. An overdose of this medicine may result in more trouble than the original disease, consequently the operators and men responsible

TABLE VI. INHIBITING EFFECT OF SODIUM PHOSPHATE ON EMBRITTLEMENT OF BOILER PLATE. STRESS ON SPECIMEN, 45,000 LB. PER SQ. IN.; STEAM PRESSURE, 500 LB.

Solution, g. NaOH per liter	Sodium Phosphate (Na_3PO_4 $10H_2O$), g. per liter	Time of Cracking	Length of Time Tested No Cracking
295	0	24 hours	...
280	2	20 hours	...
290	5	...	17 days
280	0	20 hours	...
280	10	...	13 days
280	3	...	13 days
280	5	...	13 days
280	3	...	15 days

for large power units hesitate to use acid under average conditions of operation.

When evaporators are used on alkaline water, it becomes difficult to get a water free from sodium carbonate. Table V gives the analyses of evaporated water from a few of such waters. The acid treatment of these waters is impossible. The addition of sodium sulphate defeats the purposes of evaporation, consequently a new inhibitant is sought for this type of water.

The actual ratios of salts for the prevention of embrittlement have not been determined to the point where minimum limits can be set. The results indicate that for normal pressures the A. S. M. E. recommendations are safe and should be adhered to.

The use of sodium dichromate as an inhibitive agent was suggested in Bulletin 94 of the Engineering Experiment Station of the University of Illinois and its possible action attributed to its influence on the electro-potential of the steel to caustic solutions. With this idea foremost, a list has been prepared of various chemicals which might be used in boiler waters to bring about this effect.

Tests have been conducted on a few of these salts and the results obtained have been extremely encouraging. The addition of these salts to the regular caustic solutions used brought about the results tabulated in Tables VI and VII.

The possibility of the use of these new inhibitants is at once evident, but their application in boiler feedwater treatment should not be tried until more laboratory work is in evidence and more data can be collected from plant operation. It should be realized that these figures represent data collected from the accelerated laboratory tests and are not directly applicable to operating conditions.

Causes of Embrittlement in Steam Boilers

The results that have been obtained from both embrittled boilers and laboratory investigation can be briefly summarized as follows:

a. Material has not been found to be at fault.

b. Design or workmanship of boiler is not primary cause.

c. Operation of boiler is not to blame.

d. Alkaline condition in boiler with low sulphate

TABLE VII. INHIBITING EFFECT OF TANNATE ON EMBRITTLEMENT OF BOILER PLATE. STRESS ON SPECIMEN, 45,000 LB. PER SQ. IN.; STEAM PRESSURE, 500 LB.

Solution, g. NaOH per liter	Tannate, g. per liter	Time of Cracking	Length of Time Tested, No Cracking
280	0	20 hours	...
270	50	...	10 days
275	5	20 hours	...
275	15	...	30 days
275	10	...	30 days

content is common to all embrittled boilers.

e. Sodium hydroxide is the only material encountered in the boiler which embrittles stressed steel.

1—Concentration to produce embrittlement is higher than encountered in main body of boilers.

f. Increased sulphate has been effective both in laboratory and plant in stopping this trouble.

g. New inhibiting agents have been developed.

All the data from the plants show that boilers crack in intercrystalline manner only when used on alkaline waters low in sulphates. This cracking has been stopped by increasing the sulphate or lowering the sodium hydroxide content. Plants free from it for years have suddenly encountered trouble when an alkaline water has been used. The laboratory results show that sodium hydroxide is the only chemical in the water which would cause this kind of cracking on stressed steel. A correlation of these facts shows conclusively that the offending agent has been the sodium hydroxide in the boiler. The only questions which arise are—how does the caustic act in the seams, and how does the stress exist in a magnitude sufficient to cause the caustic attack to start?

Laboratory results show that the presence of a concentration of about 4000 grams of sodium hydroxide will embrittle a piece of stressed steel. It has also been demonstrated that if the solution be allowed to penetrate between two plates as a thin film, the time of cracking and likewise the concentration necessary is reduced.

Piping for Ice and Refrigerating Plants

APPLICATION OF ELECTRIC WELDING, ACCURACY OF WORKMANSHIP AND STANDARDIZATION CHARACTERIZE REFRIGERATION PIPING AND FITTINGS

AMONG the newer developments during the past few years, in the use of piping and pipe fittings on refrigerating systems, are the extended use of welding, the standardization of fitting sizes, the employment of simpler pipe joints, the tendency toward more accurate thread fits and the increased use of steel pipe and steel forgings for flanges. Of these the newest and the most striking is the substitution of welded pipe for that having many joints.

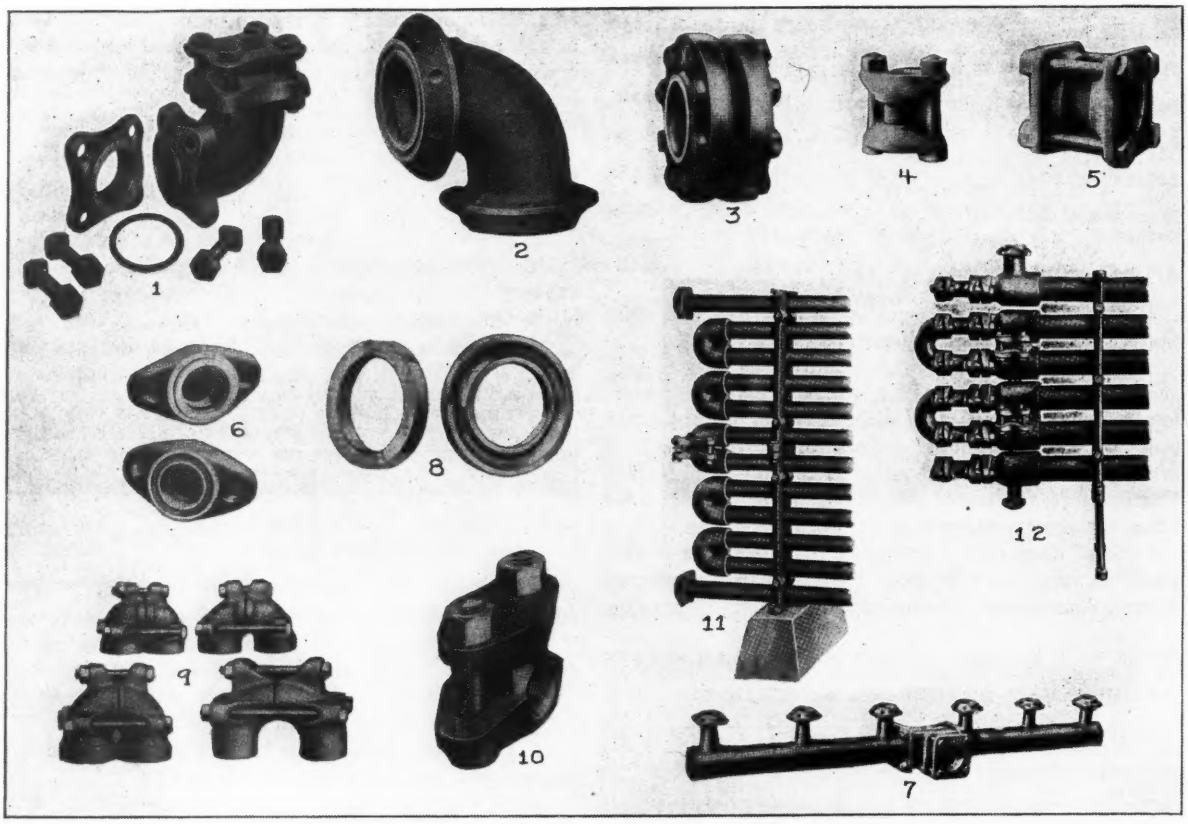


FIG. 1. TYPES OF REFRIGERATION PIPE FITTINGS

1—Flanged ell showing male and female flanges and gasket.
2—Round flanged ammonia ell.
3—Fitting of steel casting for larger CO_2 sizes.
4 and 5—Boyle type unions.
6—Oval ammonia flanges.
7—Header made by electric welding.
8—Male and female joint rings.
9—Split return bends.
10—CO_2 oval flanged screw type ell.
11—Solid and flanged return bends.
12—Double pipe connection for brine cooler.

ELECTRIC WELDING IS USED EXTENSIVELY

Most of the objection formerly raised against welding pipe connections was due to lack of reliability. This objection has been overcome by research and standardization. If standard practice is followed, high efficiency and reliability result and the joints made are practically as strong as the pipe itself. The essential thing is that the work is done under established rules by an experienced mechanic. Where butt-end welds are made the joint may be even stronger than the pipe itself because the ends are upset in welding. Some have objected to the welding process because of this upsetting action, holding that the pipe will thus be obstructed. This objection can be entirely overcome by beveling off the inner part of the ends of the pipes so that when they are brought together the outer edges will touch one another first and, becoming heated, will build up on the outside until full contact of the ends is secured. The proper amount of bevel and the proper intensities of pressure to use must be determined by trial but this may be standardized.

For pipe work, welding by the electrical resistance process, in which the ends of the pipe are brought together and electric current of high amperage and low voltage is passed from one pipe to the other, seems to be in highest favor. With this process continuous coils of great length are now produced without joints and steel flanges are thus attached to piping or headers, the headers in some cases being formed of steel plate rolled into cylindrical form and welded longitudinally. Liquid receivers are also now being made in this manner. Em-

ployment of welding in order to secure long lines of continuous piping may be expected to lead to a substitution of direct expansion piping for brine circulation piping for cooling purposes in applications where leakage is particularly dangerous or destructive, such as in the case of cold storage of food products. The torch and the electric arc also have recently been applied to refrigerating plant work with marked success in the process of cutting long established pipe lines and reclaiming this pipe for restoration in a remodeled plant.

Standardization Reduces Wastes and Costs

About 25 yr. ago, before systematic standardization of ammonia fittings was started, there was in many plants a separate drawing for each fitting and no relation existed between the pipe size and any of the other dimensions of the fitting. Under these circumstances, if for any reason a change in piping connection, such as substitution of a cross or tee for an ell, was desired, the change was likely to require the substitution of a new length of pipe. Under lack of standardization, only draftsmen who had been long in the employ of the company and who had memorized the dimensions of the fittings by number, could lay out a pipe job without unnecessary delay and even then many mistakes occurred. The importance of standardization is also emphasized not only in the greater facility of reordering parts and in actual saving of material under the system, but also in cutting pipe lengths to which a number of fittings are to be supplied. When the dimensions of fittings are standard and can be relied upon to be so, a number of pipe lengths can be cut at one time, with the assurance that when the piping has been assembled, the sections will fit neatly, without imposing undue strain on any of the parts. Modern methods of manufacturing with special machinery, jigs and fixtures assures interchangeability if sizes have previously been standardized.

Some manufacturers are standardizing their fittings so that they match similar fittings of other manufacturers. This is a very desirable step. It conforms with the efforts of the Division of Simplified Practice of the United States Department of Commerce, to reduce waste in industry by national standardization and such conformity results in universal benefit.

Cheaper Pipe Connections Most Popular

Concerns that, some years ago, used the solder joint for screwed connections exclusively, are now using litharge and glycerine. The solder joint method is expensive. It involves, first, the heating of the pipe ends and fittings in a lye solution in order to remove all grease; second, the tinning of all screwed surfaces and, after screwing the parts together, the careful insertion of the solder under heated condition. In some cases, the parts are first sweated together and afterwards the solder recess in the fitting is flushed with solder. Such a joint holds well but it is expensive and, if for any reason, it is taken apart in the plant, it is rarely resoldered correctly.

Some concerns use the solder method for all parts that can be made up in the factory, leaving the other joints to be made on the job with litharge and glycerine. Where litharge and glycerine are used, the joint holds well if the screw threads have been accurately made but such joints are harder to break after installation. The litharge is applied just as all pipe dopes are used. Its principal function, where accurate thread contact is relied upon for tightness, is not to make the joint but to act as a lubricant to enable the pipe to be screwed home. Next to accuracy of thread, it is important thoroughly to clean and wipe the threads before making the joint.

Use of tongue and grooved flange connections is universal. Most manufacturers use lead gaskets in all of their flanges; some use rubber or composition gaskets on the low pressure side of the system. Use of corrugated gaskets has superseded the practice of forming beads on the male and female rings of flanges for the purpose of securing a tight joint when the flanges which were being fastened together were not exactly in line. The beads and corrugation provide a means for causing the lead of the gasket to flow and adjust itself to the inequality of alinement.

For high-pressure systems, such as the carbon dioxide system, copper gaskets are frequently used. These copper rings are placed between the ends of the pipe itself,

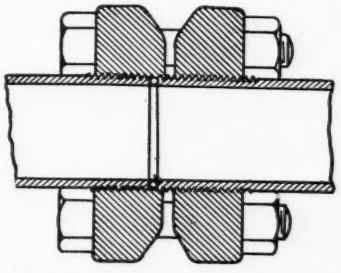


FIG. 2. CARBON-DIOXIDE FLANGE CONNECTION WITH COPPER RING GASKET

as shown in Fig. 2, the threads on the pipe being cut straight so that the flanges turn easily on them for adjustment.

Except for real small sizes, where oval flanges are used, a minimum of four bolts is usually required in flanges. Some manufacturers use eight or twelve bolts for all larger sizes, omitting the six bolt type. With the bolts so arranged, in multiples of four, the fitting may be set on any of the 90-deg. angles, thus giving a neat appearance to the pipe work.

Freedom from Impurities Important

Impurities in the metal of flanges cause leakage, therefore, where castings are used, they are generally produced in air furnaces or in the case of steel, the flanges are made of semi-steel or special grades of steel casting or are forged, in which case not only purity but density and strength are requisites obtained. Because of the cost of the dies required, only those sizes of flanges which are most used are usually drop forged. Some companies are also producing malleable iron flanges.

For ammonia systems both standard and extra heavy fittings and pipe are employed. For CO_2 systems extra heavy steel or wrought iron pipe and fittings are used. For the higher pressure used in this latter system especially, the use of welded connections is growing in favor. In some cases the size of the pipe influences the kind used. One manufacturer uses standard and heavy weight pipe for straight lengths and extra heavy pipe for connecting lines up to and including 2 in. Above 2

in., standard weight pipe is used on the low-pressure side of the system and extra heavy on the high.

Steel piping is in quite general use. One company uses American radiator sections for certain classes of work. They are used as accumulators on the tails of coils before going to the compressor. These sections are said to have good value as cooling surface and also to have a large evaporative area which tends to drop the liquid and prevent the slugs of liquor from reaching the compressor. Many make up their piping in sections, placing a flanged ell at every alternate 90-deg. bend. Use of coated and bare pipe finds advocates on both sides of the question, some recommending the use of galvanized piping; others contending that coated pipe should not be used, especially on double pipe condensers.

Infectious Eye Ailments and How to Avoid Them

By B. Franklin Royer, M. D.*

UNFORTUNATELY, the human eye is wholesomely receptive to many kinds of germs. The eye tissues lend themselves splendidly to the growth of most germs which form pus. Generally speaking, in infectious eye ailments, pus-like discharges are commonly seen on the edges of the lids, in local areas along the lashes or in the little pockets at the angle of the eye nearest the nose. Some of these eye infections are very easily transmitted to other eyes,—some of them are caused by germs so small in size that for a long while they escaped the studied search of doctors hunting for them with microscopes. It would almost appear that the smaller the germ causing eye trouble, the greater its likelihood of being transmitted from one person's eyes to the eyes of another.

Pink-eye is caused by a germ discovered almost at the same time by the great German bacteriologist, Dr. Robert Koch, while doing research work in Egypt, and by a widely known New York ophthalmologist and research worker, Dr. John Elmer Weeks. The germ causing pink-eye now carries the name of the Koch-Weeks bacillus. This is one of the tiniest germs known to invade the eye.

The germ that causes boils, the staphylococcus, may constantly be found in styes or in that inflammatory condition of the eyes where the edges of the lids are more or less crusted, with little pustules frequently developing, and where the lids and lashes often stick together in the morning. These same germs are often found in the pustular condition at the inner side of the eye where the tear duct goes down into the nose, although here the germs that cause nasal catarrah are also often found present. The germ causing pneumonia sets up severe eye trouble at times.

Some infectious eye ailments are due to direct transfer of germs from one part of the body to another. An individual with a discharging ear, either while asleep or by carelessness when awake, may readily carry pus from the ear to the eye. The child picking its nose may transfer infection directly to its eye, or those with foul teeth and sinuses discharging about them may readily soil their fingers and infect the eyes. Sometimes the route of infection is from a local collection of pus in the tonsils or in the sinuses of the nose through the circulating blood or through the lymphatic system to the eye. In any such transfer of infection the same strain of germs will be found in eye discharges as in the original focus of pus.

Chronic ulcer (phlyctenular disease) in malnourished children and trachoma have not yet been proven to be caused by germs alone.

Many eye ailments bear a very close relation to dietary faults. This relationship is not yet fully explained. The bleary-eyed children with pustules on lid edges and crusts on their lashes so commonly seen in orphanges 25 yr. ago have almost disappeared with modern feeding of children and modern hygiene in these institutions. Perhaps many germs grow best in the eyes of individuals not well nourished or with eye tissue resistance lowered from dietary faults.

All infectious eye ailments are to a certain extent a menace to vision. The strictest cleanliness is most important. Drugs applied locally for treatment should be prescribed by a physician. It is of great importance in these infectious eye ailments also, especially the more chronic ones, that constant attention be given to the diet. Diets rich in vitamins, such as an abundance of whole milk and leafy vegetables, are advised, while in winter, with the absence of sunshine and shortage of green leafy vegetables, cod liver oil should be given as a food for all children with such eye ailments.

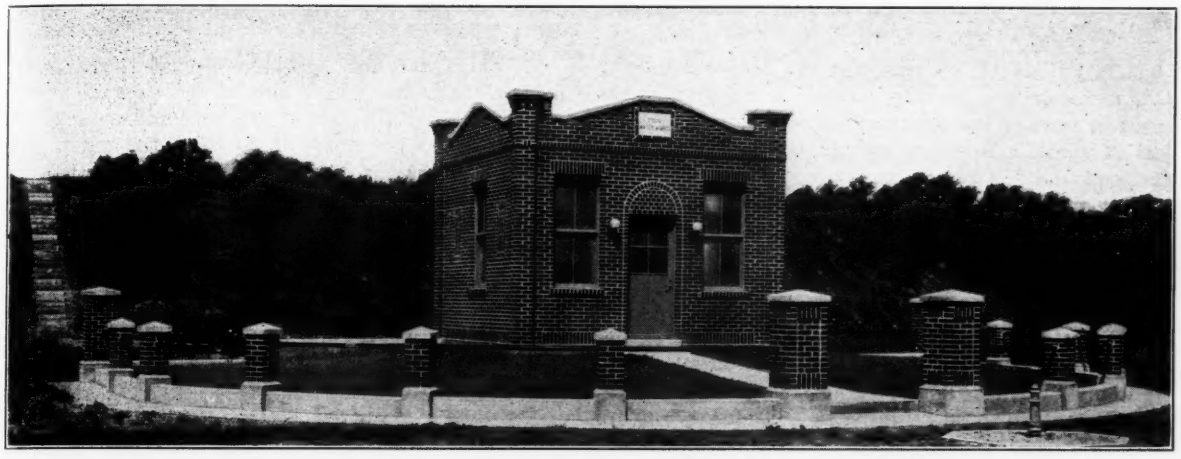
Physicians will always advise cleaning up of the local collection of pus, whether it be from the ear, tooth, tonsil or other part of the body, and will give strict instructions as to cleanliness before placing fingers to the eye. No unclean hand should ever go to an eye. No finger touching pus is safe around the eye. It is equally true that no individual with an eye discharging pus should be in close and intimate contact with those who have clean eyes. For such an individual, separate bed, towels, toilet articles, wash-basins, etc., are imperative. The danger of transfer of the infection is often great but sometimes may be known only by trial exposure, a needless menace to the other fellow's eyes.

*Medical Director, National Committee for the Prevention of Blindness.

Electrical energy production in Iowa increased nearly 60,000,000 kw-hr. last year to a total consumption of 1,403,684,400 kw-hr. and the state railroad commissions authorized construction of 827 mi. of new transmission lines with the county boards of supervisors approving 188 mi. additional, according to George Neal of Fort Dodge, vice president of the Iowa section of the National Electric Light Association, who addressed the 350 members attending the annual meeting in Cedar Rapids, Feb. 2 and 3. Iowa, with 97.7 per cent of its urban population served by electricity, enjoys the reputation of being most completely electrified state in the union, he said, pointing out that of 922 towns and cities in the state, 844 are electrified and only 38 are not served. None of these latter have over 300 population.

Toledo Edison Co., Toledo, Ohio, is planning an addition to its local steam generating station and the construction of a new transmission line between Toledo and Sandusky.

Pumping Plant Is Remotely Controlled



INDUSTRIAL EXPANSION forced Troy, Ohio, to improve its water supply. The former series of 20 half dry wells was not adequate especially during the summer months. Two 30-in. wells were therefore finally sunk by the Layne-Ohio Co. and were found to yield 1100 and 1200 gal. per min. respectively.

Duplicate pumping stations were built and each supplied with deep-well pumping units equipped with 75-hp., three-phase, 2300-v. vertical induction motors. The steel reservoir tank was built by the Pittsburgh-Des Moines Steel Co. The tank proper is 30 ft. high and 44 ft. in diameter, and has a capacity of 500,000 gal. The top of the tank is 140 ft. from the concrete base. The Central Foundry of Chicago installed the 12-in. pipe and necessary valves and fittings to connect the elevated tank to the 12-in. city mains.

In the center of the roof of each station is a ventilator through which the pump casing may be lifted if repairs are necessary. Each station is equipped with a panel on which is installed a set of Republic flow meters consisting of one indicating, one integrating and one recording meter. Above each of the panels is a pressure gage.

Automatic starting boxes, which can be controlled either from the pumping station or the station of the municipal light plant, are attached to the motors. This arrangement greatly reduces the operating cost of the waterworks since there need be no engineer in regular attendance at the pumping stations. To avoid any possible break in service the stations are supplied with two sources of current; one overhead, the other underground. The overhead line has choke-coils and lightning arresters. The switchboard is installed

in the municipal light plant, which is approximately a half mile from the pumping stations.

This water works system can be watched and checked at the pumping stations, power plant or office of the service director. A complete set of instruments has been installed. At the tank is a Republic water level indicator; at the office of the service director is a pressure gage which records the pressure in the mains; and at the power plant is a recording meter which shows the level of the water in the tank.

The tank acts as a pressure accumulator, as well as a reservoir in case of a breakdown. It is so connected to the line that water goes into the mains when more is being used than is pumped and when an over supply is being pumped the tank is filled up. Thus, by pushing a button at the light plant, 3,000,000 gal. of water is available to the city.

Several Factors Influence Radiator Efficiency

IN PROPORTIONING RADIATION SURFACES, EFFECT OF SURFACE COVERING IS OVERBALANCED BY PHYSICAL DESIGN AND LOCATION OF RADIATOR. BY B. MARKER

ALTHOUGH IT IS true that the proportioning of radiation and heating surfaces is apparently the result of more or less arbitrary approximations, a great deal of valuable investigation has been carried out in this field and the results in many cases made public. Perhaps the most talked of and most misunderstood topic directly related to this subject is the effect of various paints on radiation or heat losses from radiators.

As a matter of fact the importance of the surface covering of radiation surfaces has been greatly exaggerated, not intentionally but unintentionally, by giving only part of the complete data. In this connection data given in the A. S. H. & V. E. guide is most often quoted. These results, somewhat transposed for convenience, are given in Table I for a two-column, 38-in. cast-iron radiator ten sections long. Values for different paints are given on the basis of cast iron equal to one.

TABLE I. EFFECTS OF DIFFERENT PAINTS ON A 2-COLUMN, 38-IN., 10-SECTION RADIATOR

Paint	Heat transference ratio
Bare cast iron	1.000
Aluminum bronze	0.834
Gold bronze	0.855
Dull green enamel	0.959
Maroon japan	1.000
White enamel	1.010
White zinc paint	1.010

Expressed in unit heat transference with 215-deg. steam and 70-deg. room temperature, the value for bare cast iron is about 240. With two or more coats, the results are dependent upon the character of the last coat applied. Results are influenced not primarily by the color but by the character of the paint, all finely ground materials giving a fairly uniform high value and the flaky paints a correspondingly low value.

From a casual examination of these figures, it might appear that by changing over from aluminum to a maroon japan, a much more serviceable paint than white, it would be practical to cut down the radiation surfaces 15 per cent. This, however, is not the case, because the paint affects the radiating properties only and leaves unaltered the heat transmitted by convection. As a large proportion of the total heat loss of the radiator is by convection, the effect of radiation is reduced and becomes relatively unimportant.

FACTORS AFFECTING HEAT LOSS FROM RADIATOR

Just how the total heat loss is divided between the two depends in the main upon five factors: the nature of the surface, the physical design of the radiator, the temperature difference between the surface and the air, the location in the room and the velocity of air over the surfaces.

Of these, the first has been discussed; the second involves the width, length and arrangement of heating surfaces, largely a matter of experimental investigation. The fact that a large part of the heat transmitted is by convection and that air currents are usually from the bottom to the top, leads to the immediate conclusion that the unit heat transfer for short radiators is greater than for tall ones. Naturally, the cold air coming in contact with the bottom of the radiator warms up as it rises,

TABLE II. EFFECT OF WIDTH ON HEAT TRANSFERENCE. PIPE COIL TAKEN AS 1

Type	Heat transference ratio
Pipe coil	1.00
Wall coil	0.88
Single column	0.82
Double column	0.75
Three column	0.71
Four column	0.67

thereby giving a lower temperature difference at the top and making this portion relatively less important than the bottom.

More heat is radiated per unit of surface from a pipe coil or single-column radiator than from wider designs because the heat rays from these have an unobstructed travel in any direction. On a multi-column radiator

TABLE III. EFFECT OF LENGTH ON HEAT TRANSFERENCE

Sections long	Heat transference ratio
1	1.000
2	0.76
3	0.70
4	0.66
5	0.645
6	0.63
8	0.615
10	0.60
12	0.593
15	0.585
20	0.575

many of the rays fall upon other parts of the radiator and cut down the effective area. Heat radiated is not a function of the total surface but is nearly proportional to the area of an imaginary envelope or cover taking in the entire radiator.

Effect of width is shown by Table II on the basis that heat transmission of a pipe coil equals 1.0. These figures represent total heat transmission, of course, but as convection conditions remain practically constant, the differences represent changes of radiated heat. On this

basis, if the heat transmission unit is taken as 315 for a pipe coil, the corresponding value for a four-column radiator would be only 210 B.t.u. per sq. ft. per hr.

Effect of Length

Again, the length of the radiator is not to be neglected as shown by Table III. This is due to the larger proportion of radiation surface to convection surface on account of the end areas. This item is of the utmost importance for between six and ten sections. Beyond ten its importance is negligible, while below six its effect is so noticeable that little thought is necessary to determine the best length to use. The relative effect of length remains practically constant regardless of height. Under the usual conditions encountered in service, the heat transference of a single section would be in the neighborhood of 400 B.t.u. per square foot per hour.

If the length is increased by wider spacing, the effect is the same as decreasing the number of sections and an increase from the standard 2½ in. to 3 in., as in hospital radiators, increases the heat transference about 7 per cent.

Changes in radiation effect are responsible for the above variations while convection effects are changed by the location of the radiator in the room and various methods of shielding or enclosing. By increasing the velocity of the air currents, the convection heat losses are increased and the radiators made more effective. Changes in air density due to humidity have some effect as well. Screens decrease radiation losses but, if properly designed, may produce air currents or draft, like a chimney, and thus give increased circulation.

In actual installations the proportion of radiant heat varies from 25 to 50 per cent of the total heat loss. This means that the 20 per cent increase in radiation by changing from the poorest paint to the best paint decreased to an actual value of but 5 or 10 per cent of the total. This is, of course, important and worth considering but its relative importance is much overshadowed by other factors.

Hot Water Requirements

WHEN ARRANGING for a hot water supply it is important to know the amount required in various establishments and for various purposes. For industrial needs in process work, general data cannot be given because of variation of individual plant needs and the experience of storage heater manufacturers should be utilized in making a decision. One principle is universal, however; lack of sufficient hot water is always uneconomical.

For building use, experience of the MacDonald Corp. in furnishing heaters is embodied in the accompanying table from its bulletin No. 703. These averages are now generally used as a guide in selecting water heating equipment unless special requirements are to be met.

ESTIMATED HOT WATER REQUIREMENTS

	TYPE OF BUILDING																		
	Apartment House	Church	Club	Department Store	Depot	Dormitory	Garage	Gymnasium	Hospital	Hotel	Industrial Plant	Laundry	Loft Building	Office Building	Public Bath	Residence	Restaurant	School	Theatre
FIXTURE	MAXIMUM GALLONS PER HOUR PER FIXTURE																		
Dish Washer	15	..	30	..	..	..	..	..	30	30	30	..	..	..	..	15	300 Gallons per 500 people per hour 500 Gallons per 1000 people per hour	15	..
Pantry Sink	10	..	20	..	..	..	..	..	20	20	..	..	..	..	..	10		20	..
Kitchen Sink	10	..	20	..	..	..	..	..	20	20	20	..	..	..	..	10		10	..
Slop Sink	20	10	20	20	20	15	..	..	20	30	20	10	20	15	15	15		20	15
Wash Basin—Private	3	..	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3
Wash Basin—Public	5	5	8	8	10	10	12	10	8	10	15	10	10	8	15	..		18	5
Bath Tub	15	..	15	..	..	30	..	30	15	15	30	..	..	..	45	15		..	..
Shower Bath	50	100	200	..	100	200	150	200	50	50	200	..	150	..	200	50		200	..
Foot Basin	3	..	3	..	..	3	..	12	3	3	12	..	..	..	..	3		3	..
Laundry Tub—Stationary	25	..	35	..	..	35	..	..	35	35	..	40	..	..	..	25		..	..
Laundry Tub—Revolving	75	..	75	..	..	100	..	..	125	150	..	150	..	..	100	75		..	..
Wash Racks	30	..	..	..	..	..	50	..	..	..	..	30	..	..	..	..		..	..
Water Heating Capacity in Gallons Per Hour as a Percent of Demand on All Fixtures at One Time %	20	80	50	50	60	75	80	80	60	50	90	100	80	15	100	50		25	75
Tank Storage Capacity in Gallons as a Percent of Water Heating Capacity %	100	50	75	75	50	50	50	50	50	25	50	25	50	100	50	100		50	75

Preliminary figures of the total annual production of electricity by public-utility power plants in the United States issued by the U. S. Geological Survey indicate an output of 79,724,000,000 kw-hr. in 1927, an increase of 8 per cent over the output for 1926. Of this quantity 37 per cent was produced by the use of water power, an increase of 1.6 per cent over the proportion for 1926. In kilowatt-hours the electricity produced by the use of fuel increased about 5½ per cent, and the electricity produced by water power increased about 13 per cent. It would have required about 27,000,000 t. of coal to generate the electricity which was produced by the use of water power.

The improvement in the average utilization of fuels that has been brought about by improvements in plant design and operation during the last few years continued in 1927. The operators of public-utility power plants performed the remarkable feat of generating about 2½ billion more kilowatt-hours of electricity by the use of fuel in 1927 than in 1926 by the consumption of about 150,000 t. of fuel less than was used in 1926.

If you are misunderstood, it is generally your own fault.

Effect of Bad Condenser Water Conditions

REPLIES WITH DATA in answer to a questionnaire sent out by the A. S. M. E. Special Research Committee on Condenser Tubes were received from 240 plants. Of these only 141 reported failures, and the information submitted from 141 plants has been compiled and presented in tabular form.

Of the 2,400,895 tubes reported, 1,057,435 were Admiralty, 849,199 were Muntz metal and the remainder unclassified. Of these, 882,792 were installed in tidal waters and 1,518,103 in fresh water. Classification as to size was 1,312,202 for 1 in., 117,744 for ¾ in., 11,924 for ⅝ in. and 959,023 for miscellaneous sizes. Therefore, of the 1,441,873 tubes possible to classify, 91.1 per cent were 1 in. o.d.

Cleaning methods vary, the most common method employed being the shooting of metal, metal and canvas, rubber or rubber and canvas plugs through the tubes by air or water under pressure. In cases where the deposit on the tubes is oily or of a very slimy nature, this method of cleaning is not quite successful and a more rigorous cleaning is given annually or semi-annually by sand blasting or wire brushes. Where extremely hard deposits of scale are found, turbining or drilling out of the scale is resorted to. Frequency of cleaning methods is given in the following table:

TABLE I. FREQUENCY OF CLEANING AS REPORTED BY 141 PLANTS

Intervals	Plants	Per cent
Semi-weekly	11	7.8
Weekly	28	19.9
Semi-monthly	19	13.5
Monthly	28	19.9
Three months	12	8.5
Semi-annually	8	5.6
Annually	9	6.4
Irregularly	17	12
No cleaning	9	6.4
Total	141	100

Stations on the seaboard report bad water conditions ranging from natural to highly polluted water near the large cities. Tube replacements are heavy throughout this section, of 41 stations reporting, five had average yearly replacements in excess of 20 per cent and 1 had replacements of over 30 per cent. The average replacements were 1.1 for Metropolitan area, 4.5 for the Atlantic Coast other than Metropolitan, 5.5 for the Gulf States and 10.0 for the Pacific Coast.

Of 21 stations in the Great Lakes section, three reported average replacements yearly of over 1 per cent, nine reported negligible failures. East Chicago has serious troubles from corrosion and erosion and reports the highest failures and tube replacement of this section, 11.65 per cent. The replacement of the entire section as reported was 0.5 per cent. Of 38 stations reporting in the Mississippi Valley section, 6 have yearly average replacements of over 1 per cent and 5 of over 10 per cent. Nearly all of the companies reporting high replacements are located in the manufacturing districts on the Ohio River and tributaries. The type of failures in these districts included corrosion, erosion and splitting. The average percentage of failures in this section is 4.4 per cent on the west side and 3.5 per cent on the east side of the Mississippi River.

With tidal water the Atlantic, Metropolitan and Pacific districts reported major replacements from corrosion, while the Atlantic district other than the Metropolitan reported major replacements due to scale. The Gulf district reported trouble from erosion. Corrosion or corrosion and splitting was the cause of the majority of failures in practically all of the fresh water districts.

By far the greatest number of failures were reported as due to corrosion, replacements based on the total number of tubes installed being given as 2.5, 0.7, 0.2 and 0.2 per cent respectively for corrosion, end corrosion, erosion and splitting.

Blowing Down and Cleaning of Boilers

By H. R. Williams

ELEMENTS that cause scale in the boilers are those which are non-volatile or, in other words, those that do volatilize with the steam but remain in the boiler. Blowing down of boilers should be regulated by the amount of these scale-forming elements.

In many cases where trouble is reported, an investigation shows that the boilers are not being blown down regularly. In the case of horizontal water-tube boilers, they should always be blown first from the mud drum valve, and as that valve is closed, the water leg blow valve should be opened so as to carry out all substances which were thrown to the back water leg when the upper blowoff valve was open.

When the fire is first pulled from a boiler, agitation and circulation of the water in the drums soon ceases. At or nearing this point the accumulation of foreign matter, which is part scale forming elements held in suspension in the water, begins to settle, lodging on the tubes and shell of the boiler where the intense heat soon hardens it.

For this reason it is considered good practice to blow the boiler down at least two gages soon after pulling the fire. In fact, it may be advisable to blow down several times, depending on the amount of dirt in the water. The water should then be allowed to stay in the boiler until it is ready to open and, when the valve is open to let the water out, the top manhead should be opened and a hose inserted to wash the boiler down as the water level drops. This removes what scale forming elements there are on the shell while in a wet soft condition. If water is allowed to go down without washing and the boiler opened and dried, all substances on the metal will immediately harden and in many cases it will be impossible to remove them except by mechanical means.

After the boiler is thoroughly washed out and left open to dry for a while, a second washing of the dry boiler will assist in cracking off a large part of the remaining scale.

Large Gear Remodeled in Place by Oxygen Lance

WHAT AT FIRST appeared to be a serious and costly emergency in a steel mill was reduced to four hours' lost working time with small charge for material and labor by the use of the oxy-acetylene process. On a Saturday morning in the sheet and tin plate mill of a large steel plant, a 23-ft. diameter steel gear started to slip. A hasty inspection disclosed that the gear was already drawn up as far as possible and that it would be necessary to remove metal from one section of the split hub in order to tighten the gear on the shaft.

Taking the gear apart, transporting it to the machine shop and removing ¾ in. of metal from one section of the split hub with a planer and reerecting it would

FIG. 1. CUTTING EXCESS METAL FROM THE GEAR HUB WITH AN OXYGEN LANCE

FIG. 2. FINISHED CUT AFTER 470 CU. IN. OF CAST IRON HAD BEEN REMOVED FROM THE HUB

take four days with a cost estimated at $2000. Since the plant was operated on 100 per cent production basis, stoppage of work on Monday, Tuesday and Wednesday would have meant a further loss to the plant of about $15,000 profits from the material normally produced in these three days, as well as a much greater loss because of delayed production schedules.

After investigation, a welding service engineer reported that the excess metal could be removed by means of a cutting blow pipe supported by an oxygen lance. The necessary equipment was assembled and work started. It required 14 hours' labor for five men to do the job of cutting, and the total cost of the work, including, oxygen, acetylene, labor and steel pipe for the oxygen lamp amounted to about $110. The size of the gear is shown in Fig. 1.

The section cut out as shown in Fig. 2, was 3 ft. 11 in. in greatest length. The cutting blow pipe removed altogether about 470 cu. in. of cast iron from the hub. The cost of the oxyacetylene cutting was a trifle over 1/20 of the estimated cost of machining and handling in the machine shop. The job was completed by Sunday afternoon and the gear was back in place and ready for operation Monday morning.

Status of Hydro-Electric Development*

POINT OF VIEW OF THE FEDERAL POWER COMMISSION. BY GLEN EDGAR EDGERTON, MAJOR, CORPS OF ENGINEERS, U. S. A.; CHIEF ENGINEER, FEDERAL POWER COMMISSION

AUTHORITY of the United States in the matter of water-power development is derived from the provisions of the Constitution, which give the Federal Government complete control of the lands and other property belonging to the United States; the right to exercise jurisdiction over navigable waters in the interests of interstate and foreign commerce; and the control of the international boundary waters as an adjunct of the treaty-making powers. If a power development affects any one of these three interests, it falls within the paramount jurisdiction of the National Government.

The Federal water power act of June 10, 1920, prescribes the policy of the National Government in the exercise of its authority over water power. The policy may be briefly stated as providing for the development of such resources in accordance with the laws of the several states by private or municipal capital under conditions which secure the most beneficial uses of the water resources involved, protect the capital investment without relinquishing the Government's authority, and prevent the evasion of public supervision of the rates and services of public utilities. This policy does not anticipate the development of power by the Government, except in unusual cases, in which a procedure for the initiation of special legislation is provided.

By this act the Federal Power Commssion was established as the agency through which the jurisdiction of Congress is exercised more promptly and effectively than if each case required special legislation. The act applies to water power only, and the Commission, having authority in that field alone, can not authorize even the construction or operation of a transmission line if it is to be used solely for fuel-generated power.

NATIONAL AGENCY TO AID DEVELOPMENT

The Federal Power Commission, therefore, views this subject from the standpoint of the national agency established to facilitate the development and use, under proper regulation, of those water-power resources that may not be developed without the consent of the Government.

As to physical conditions, therefore, we have at present approximately 16 per cent of our potential water-power resources developed, at least 5 per cent in process of development, and about 8 per cent more under investigation with a view to early development. The completed hydro projects of all kinds appear to be supplying in the neighborhood of one-third of the total quantity of electrical energy generated in this country.

No consideration of the subject would be complete if it were restricted to the physical condition alone. Attention must also be given to the legal situation. The

*Abstract of paper presented at the Midwest Power Conference.

general terms of the Federal legislation, the Federal water power act, have already been indicated. They have been in effect for nearly eight years and little criticism of a practical or constructive nature has been made concerning the important provisions of this law. It may be stated confidently that the policy enunciated in the act is favorable to the development and use of water powers. There is, however, a noticeable tendency to withhold important power resources from the immediate application of this sound and effective general policy.

Whether or not they come within the scope of the authority of the Federal Power Commission, water-power developments must be made in compliance with the laws of the States in which they are located. The National law emphasizes this fact by specifically requiring the Commission to secure satisfactory evidence of compliance with state laws concerning the use of the bed and banks of streams, the appropriation of water, and the right to engage in business, upon the part of each prospective licensee. In the forty-eight states there are almost as many varieties of laws of this kind.

No Radical Changes Anticipated

There appears to be little reason to anticipate radical change in the status of hydro-electric development in the near future. No evidence is observed that there is any general falling off in the rate of growth in the demand for electrical energy. On the contrary, the higher standards of living in this country, the educational campaigns that have taught potential consumers the benefits of electrical service, the development of new types of electrical equipment, both household and industrial, and the growing tendency to substitute electrical power for mechanical power and human labor, all point towards a healthy growth in the entire electrical industry. The rapid extensions of arrangements for interconnection and interchange of power, which permit the utilization of the large quantities of secondary power that characterize many water-power developments, the prevailing low rates of interest required to attract capital to public utility investments, and the adaptation of navigation projects to permit the use of the structures for power development as well as navigation, are all factors which give confidence that water power will keep pace with the rest of the electrical industry.

On the other hand, recent improvements in the efficiencies of fuel generating plants, and still higher efficiencies that seem to be just ahead, together with marked decreases in the capital cost per kilowatt, may serve to accelerate the development of fuel generation at the expense of hydro. The growth of hydro development will also be unfavorably influenced by the preemption and development of the more economical sites, leaving always the less attractive ones for the future.

Aside from strictly economic considerations, it is reasonable to hope that problems like those of the Colorado, Tennessee, and St. Lawrence rivers will be settled in such a way as to remove the artificial obstacles which now prevent their effective use for power purposes. While there may have been a recent tendency in some states to enact legislation unfavorable to water power, it seems probable that this may indicate merely the awakening of public interest. Any errors that may have been made will undoubtedly be corrected when the relative values of water and fuel in power production are more generally understood.

On the whole, the present status of hydro-electric development is, perhaps, satisfactory; it can scarcely be described as gratifying. The present and prospective rates of development compare not unfavorably with those of steam power, but only a small part of the potential water-power resources of the country has actually been put to use. Political considerations still prevent the application of the principles of the Federal water power act to some of our major water powers, and the states do not all exert their extensive authority in the field of water power wisely and effectively. It is the aim of the Federal Power Commission to further the development of water power as extensively as economic conditions will permit. That objective can be attained only if the states adopt a similar policy and if the existing restrictions upon important power streams are permanently removed.

Ten Commandments for Plant Executives

FROM a large factory in San Francisco comes what is called the "Ten Commandments for Foremen," which are posted conspicuously in the superintendent's office. Of such indisputable value are they we are reprinting them here since they might well be adopted by nearly every establishment. Needless to say, if every foreman strictly obeyed these commands at all times, the present excessive cost of labor turnover would be largely eliminated. The "Commandments" follow:

1. Be fair. Have no favorites and no scapegoats. A foreman must act as judge many times every day; therefore, he must be fair.

2. Make few promises and keep them. Foremen must be exact in this particular. Never forget that your job requires a high standard of truth and honor.

3. Don't waste anger—use it. Anger is valuable and should not be used carelessly. Keep your most forceful language for special occasions.

4. Always hear the other side. Never blame a worker until he has had time to give his own point of view.

5. Don't hold spite. When you have to scold a worker, go to him and show him his faults in a friendly way.

6. Never show disappointment. Never let yourself be beaten. A foreman must have perseverance and the "never-say-die" spirit.

7. Notice the good work as well as the bad. Let the workers see that you can appreciate as well as condemn.

8. Watch for special ability. Take a keen interest in your workers. Put each one where he can do his best.

9. Take your full share of the blame. This is the most difficult of all. The foreman who can share both blame and praise with his workers has discovered the secret of managing men.

10. Prevent accidents. Educate or eliminate the careless man. The good foreman is known by his men and the work they do.

Procedure in Starting Up a New Generator

IN THE ISSUE of Feb. 15, 1928, Marin Phillips, in Part III of a series of articles under the above title, shows, in Figs. 1—6, certain diagrams of methods for synchronizing and phasing out generators. The methods indicated are correct and these comments are not intended as criticism but from a practical viewpoint they may be pertinent in bringing the methods closer to a real application as required by the average operator.

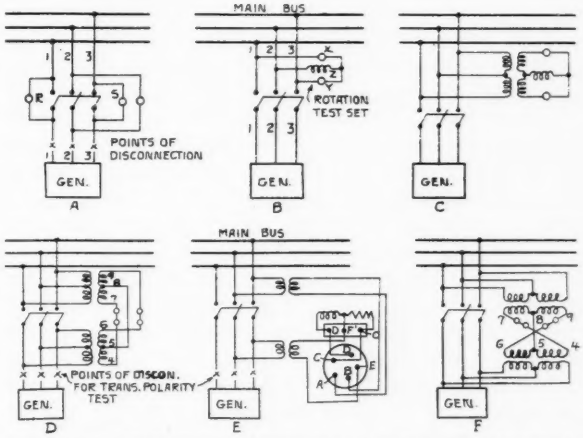
The general fundamentals are stated in the second paragraph of the article, namely that "First the frequency must be the same and second, the phase rotation must be the same." These statements are correct but a third should be added, i.e., the voltage of the incoming unit should be the same as or as close to that of the unit in operation as experience indicates is advisable to assure the least disturbance to the system.

It is not unusual that the final phasing out of a new unit, before it is finally put into service, is done under pressure or under conditions which are likely to put the skill and judgment of the one in charge to a severe test, hence it is particularly desirable to use methods which are beyond question and allow, in themselves, checks to be made which will definitely assure and make positively certain a satisfactory result.

Referring to diagram B, which is a substitute for Fig. 3 in the article referred to, the motor is here replaced by two lamps or two series of lamps of the correct voltage for the circuit and a reactor which may be the trip coil of an oil circuit breaker or the coil of a plunger relay, in fact, any type of reactor suitable for the voltage of the circuit. If the rotation of the three-phase circuit is 1-2-3, lamp X will be bright and lamp Y will be dim; if it is 3-2-1, lamp Y will be bright and X will be dim. In other words, we have here a rotation testing outfit which can be made up of the simplest type of equipment, in fact, the writer has used two lamps in the ordinary weather-proof socket and the trip coil of a breaker. The advantage of this equipment over a motor is its extreme simplicity and portability. Diagram C shows the same method using potential transformers. Both of the methods indicated in B and C are used the same way that those in Figs. 3 and 5 in the original article are used.

Diagram A, which is the equivalent of Fig. 1 in the article, brings out a point which is very often overlooked in phasing out units, namely, that of the difficulty of checking polarity when it is difficult to trace the leads. If the incoming generator leads are disconnected at its terminals, the main switch or breaker may be safely closed. The lamps will then indicate the exact condition at synchronism and, if a connection has been incorrectly made, one or more of the lamps in this method will burn, if, for instance, lamp R had been connected 1-2 instead of 1-1, or lamp S to 2-3 instead of 3-3. This may seem an unnecessary test, but experience indicates that it is well worth the trouble involved.

Diagram D is intended to show a method which is in general the same as the one shown in Fig. 4 of the original article. Its advantage lies in the fact that standard potential transformers can be used. Although



DIAGRAMS SHOWING CONNECTIONS USED IN SYNCHRONIZING AND PHASING OUT GENERATORS

not definitely stated in the original article, the method shown in Fig. 4 would require 4600-v. potential transformers. The writer recently had to phase out a 13,200-v. generator, which would have required three 26,400-v. transformers for the method shown in Fig. 1, or six 13,200-v. transformers connected in three groups of two in series; the method shown in diagram D allowed the use of four standard 13,200-v. transformers, two of which were installed with the new generator and the other two were already connected to the existing bus.

To make sure of the connections of this method the generator terminals may be disconnected and the main switch closed, the lamps will then show the conditions as they would exist at synchronism in a similar manner as previously described for diagram A, and will settle once and for all the question of the relative polarity of the potential transformers. If the lamps do not all burn brightly or are dark as desired, the connections can be changed to obtain the condition desired, either on the high or low voltage side of one set. When the lamps give the condition desired at synchronism, the main switch is opened and the incoming machine re-

connected and brought up to speed; if its phase rotation is not the same as the existing bus, the lamps will not show the same conditions as was obtained during the polarity test and two of its leads must be interchanged.

This method of testing the polarity of the potential transformers is particularly desirable when transformers of different makes are in use and also as even the most careful factory inspection will sometimes permit apparatus to leave with incorrect polarity markings.

After the phase rotation of a generator has been checked, the operation of a synchroscope, if one is used, must also be checked. Since this instrument is of the single phase type it is always best to do so as shown at E by disconnecting the generator leads at its terminals and closing the main switch or breaker; as in the case of the lamps in diagram D, the instrument will show its position at synchronism and it is not an unusual occurrence to have the pointer take its position at the bottom of the face instead of at the zero position at the top. This condition is readily corrected by interchanging the incoming generator potential transformer leads at F^1 and E^1 at the synchroscope.

It will be noted that the advantage in making the tests in diagrams D and E lies in the fact that the potential transformers can be connected at random without any actual previous knowledge of their relative polarity.

An interesting feature in connection with the method shown in diagram D is in the relation of the connections on the low voltage side of the potential transformers when they are mounted with the low voltage sides facing one another. In diagram D they are shown symmetrically placed; in diagram F they are shown with the low voltage terminals facing each other. It is necessary therefore to cross the leads as indicated if all transformers have the same relative polarity. This condition can be readily checked by following the numbering of the respective terminals. In actual practice they can be readily checked by the methods here outlined.

Brooklyn, N. Y. C. O. VON DANNENBERG.

Examinations for Operating Engineers

THE EDITORIAL comment on "Examinations for Operating Engineers" in the March 1 issue recalls to my mind an old catch question that used to be and probably still is, asked at nearly every examination for engineer's license. "What is the most important nut on an engine?" An engineer up for his first license before the examiners would silently name every nut on an engine and after deciding that one nut was just as important as another, would answer "I don't know," and have the examiner say to him, "A loose one, young feller, a loose one." And didn't we feel foolish then? All over the country we find questions asked by every examiner that are just as silly.

Where is the engineer who has not answered questions satisfactorily to the examiner and then operated his boilers just the reverse to the answers he gave in the examination? I remember an incident that occurred when I was employed in a city ranking very high in automobile production. Coming on watch in the morning, I was met by the chief, who said that the night fireman had let the water get low in our No. 2 Stirling boiler and burned out the fusible plug. When I told him there was no plug in that particular boiler, his pressure began to rise. After he had popped off for about 10 minutes, we examined the boiler and found a tube ruptured in the front bank. When the boiler had cooled down we inspected it very thoroughly (as I had done before) and found not only no fusible plug but not even a hole drilled and tapped for one. And this in a city where there is or was a rigid inspection law! Now, the examiner was one of those hard-boiled old timers who call a spade a spade. Had I told him I would operate a boiler under those conditions, when he was examining me for a license, do you think he would have given it to me? Not much.

In my opinion, there should be a standard set of questions asked each applicant for an engineer's license. These questions should be standard everywhere there is a license law, just as the boiler code is enforced. In that manner we would do away with the foolish questions. They certainly do not in any way prove the ability of an engineer to operate machinery safely.

Louisville, Ky. FRED E. BOND.

Piping Connections for Sampling Flue Gas

REGARDING Mr. Emmarr's reference to my article, "Piping Connections for Sampling Flue Gas," published on page 1161 of the November 1 issue, I must return his compliment. We have encountered no trouble by having two high pressure lines on our apparatus, and, as a matter of fact, we find that the steam line is very seldom used, air being able to meet our requirements and being our original installation, was regularly used. I might add that the steam was added to make our apparatus the more dependable.

Perhaps my original article should have mentioned the fact that our steam supply is disconnected at its source, except when it is required, because this is a high pressure line and I am sure that Mr. Emmarr could not consider a high pressure steam line a more convenient apparatus than an ordinary air line, particularly when the air is more accessible, as in our case. With our method we have no need for any disconnections every time our line is used, with a result that it is used more frequently, thereby giving us better maintenance of the line in question and a possibility of obtaining gas analyses easier and quicker on our extremely regular gas testing.

To take Mr. Emmarr's second item, I have covered this pretty well and while I agree with him on the cleansing effect of steam, I still maintain that the use of high pressure steam is out of the question for routine line cleaning, particularly where air is readily available, as on the installation in question. I do not believe any Orsat can obtain a quicker or more dependable sample than on our installation and I believe the installation quite sufficient in itself for we have made many different attempts of the nature described by Mr. Emmarr and have discarded all of them in favor of our present system; I assuredly cannot agree with him about interchanging hot ends to prevent plugging, as our maintenance men have more necessary duties to perform.

As to his third item, I assumed that the frequent use

of our simple air line so excludes the possibility of the formation of oxides, due to entirely changing the air within the line prior to sampling that we have no dead air remaining, consequently have a good sample showing the immediate furnace condition with no time lag due to dead air in the sampling pipe. I am sorry that I cannot agree with this writer regarding sampling of air at the breeching in spite of the lower temperature. As a matter of fact, our regular tests are made in the last pass, these are followed by periodic tests at the breeching and their agreement gives us much information, but their disagreement gives us considerably more and while samples may be taken at the breeching, they will agree only so long as no air leaks are allowing a change of the gas content up to that point. The conditions we actually want are in the last pass and we hope they are the same at the breeching, but both places must be checked for assurance, regardless of the heat. I am also sure that Mr. Emmarr will find that water-cooled sampling tubes would provide a terrible maintenance problem unless he used pure water for this cooling, otherwise scale, etc., would make them useless in a short while.

Aurora, Ill. E. J. Morrissey.

Locate Boiler Feed Pumps Conveniently

In isolated steam plants, particularly of the smaller types, there seems to be an almost universal practice of placing the steam pump with which the boiler is fed, in some obscure, out-of-the-way corner, sometimes under a flight of stairs and often so close to one or even two walls that a person cannot get behind the pump when repair work must be done there. The writer has ofttimes found it impossible to remove a piston or a rod for repairs without removing the pump from its foundation, or without knocking a hole through the wall of the building. In some instances, instead of replacing boards or bricks, a frame would be built into the hole and a small window, door or shutter, removably placed therein.

In all the small isolated plants which the writer has constructed, he has always placed the boiler feed pump out in the open, where it could be easily gotten at from all sides. The matter was also carried farther for, instead of placing the feed pump upon the floor or ground, a foundation would be built up high enough that a man could work at the pump without bending or squatting. When such a foundation was built, either of brick or of concrete, small anchor bolts would be built in to receive a top surface of heavy plank or a timber, which would be permanently fastened to the foundation by the anchor-bolts already mentioned. Such construction permitted any pump to be fastened in place by means of lag screws and, in connecting up a pump, it is often found a great convenience to be able to move the pump an inch or so, in one direction or another. With built-in anchor bolts, it is sometimes awkward to change anchor bolts to receive a new pump.

When erecting a boiler feed pump, give a lot of thought to the piping and its connections. Aim to keep the piping as simple and direct as possible. Don't overlook some necessary connection and then have to put in one of the "crazy-quilt patchwork" layouts of pipe and fittings, all too often found around boiler feed pumps.

Never screw a piece of pipe into place around a feed pump or anywhere else, without first reaming both ends of the piece of pipe until full opening had been obtained. Do not use either red lead or litharge for coating pipe-threads before screwing them together. Use good clean graphite, either of the flake or the powdered kind and mix with ordinary machine oil, never with linseed or any other "drying" oil. Mix the graphite to the consistency of a paste with the oil, until the mixture will neither "run" nor "crumble" when placed upon the pipe threads.

It is a pipe-fitter's rule never to put red lead "dope" into internal threads, the penalty for so doing being sometimes the partial closing of a pipe with a clot of red-lead which has been forced from between the threads and collected in a ball in some nearby fitting.

The writer has found it preferable when fitting feed pump piping, to apply the graphite and oil with a very small and stiff-bristled brush similar to the brushes which accompany bottles of mucilage. Sparingly but completely, paint about five or six threads, both on the pipe and in the fitting, then screw them together and a tight joint will result, with no mixture in the threads to harden and make it difficult or impossible to "break-out" a joint, without perhaps spoiling a piece of pipe or a fitting.

Never have a "built-in" pipe in a pump foundation. If necessary or convenient to run a pipe through the foundation, pass the pipe through a hole large enough to permit the necessary movements which accompany making up screwed pipe connections. If you are obliged to tolerate some underground pipes, never make the mistake of burying the pipes in the ground. Place the pipes in some kind of conduit where the pipes are convenient and where there is room enough to insert a pipe wrench.

Indianapolis, Ind. James F. Hobart.

Pneumatic Coal Handling

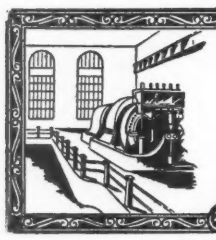
We have noticed the article on the above subject which was published on page 173 of your Feb. 1 issue and is a resume of one that had been published in Engineering of London. The system described was experimented with in this country about 25 yr. ago and all such installations of which we have knowledge have long since been discarded. The item of power cost which your article says is against the system is perhaps the most lenient indictment.

One of the most serious of its disadvantages is that wet coal will stick in the pipe and plug up the system and American practice today demands the handling of wet sticky and increasingly lower grades of coal. The system is essentially a low-capacity system which is against American trends. Furthermore, the system will not handle lump coal.

Philadelphia, Pa. H. S. Ford.

The Pennsylvania Water & Power Co., Holtwood, Pa., is completing plans for a proposed new hydroelectric plant at Safe Harbor on the Susquehanna River, about 9 mi. above the present Holtwood Station. It is expected that the station will cost about $20,000,000.

Never guess. Guessing is gambling. It is better to know than to guess.

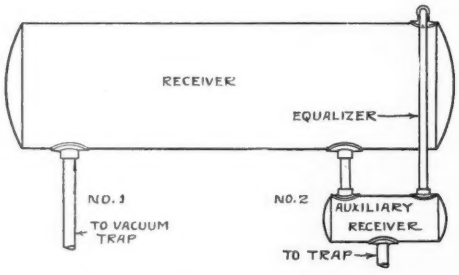


QUESTIONS AND ANSWERS

Steam Plant Operation

IN LOOKING through the February 15 issue, I notice a question or two on page 263 which I wish to answer in a different way.

It has been my experience, covering 30 yr., to have a partial vacuum in the receiver of a compound engine as often as four or five times in one hour. This condition obtains in suburban electric power stations and in the rolling mills. Shortening the cutoff on the low-pressure cylinder, under normal running conditions, would cause



RECEIVER CONNECTIONS EITHER ONE OF WHICH MAY BE USED BUT WITHOUT WHICH, AN INSTALLATION IS A POOR INVESTMENT

the receiver pressure to rise, but when the load drops off from 125 per cent to 10 per cent, the above mentioned adjustment fails.

By the second question, on lubrication, one would expect that the first question was answered, but such is not the case. To be sure, when the pressure fails in the low-pressure cylinder, atomization of the oil fails and lubrication is at a disadvantage but force feed lubricators and hand pumps have helped to eliminate scoring. When the receiver is under a partial vacuum, and condensation is taking place more rapidly, where does it (the condensation) go? If an auxiliary drum, as shown in the sketch, is employed so as to hold all the condensation that forms between the low load periods, trouble may possibly be avoided; but it is not uncommon practice to use a vacuum trap to discharge this water. It is possible that some low-pressure heads have been ruptured through this very cause, although the mechanical coroner called it "water from the condenser."

Under the caption "Inertia Governor vs. Centrifugal Governor" the answer is perhaps somewhat misleading. It seems to me that two of the most prominent builders of engines with riding cutoff valves used centrifugal governors. The reason I say "used" is because one of these builders has since taken up another line.

While I write these few lines, a very large engine with riding cutoff valves is nearby and the governor is not only centrifugal but it is equipped with a pair of extremely large gag pots.

New York City. JOE BROWN.

Shavings and Sawdust as Fuel

DURING the past July, we installed a 72 in. by 18-ft. h.r.t. boiler, using a 28-in. setting. In the front of this boiler is an opening 5 by 10 in., that is 8 in. above right fire door, one half over door and one half to right of door. A spout goes through the front arch directly into the furnace. Shavings and sawdust are blown through this cast-iron spout with enough air from a 72-in. blower to carry them through a pipe on the roof that has a fall of 3 ft. 6 in. in 16 ft. We would like to know the effect this amount of air has on combustion and what you would suggest to improve conditions. L. P.

A. You are using entirely too much air and your combustion space is too small. Theoretically you should require only 6 lb. of air per lb. of wood. In practice, due to impurities in fuel and the difficulties of getting air into contact with all the particles, it is impossible to obtain perfect combustion with the theoretical amount of air and an excess amount, sometimes equal to double the theoretical amount, is required. Usually in a properly designed furnace, about 50 per cent excess air is sufficient to meet requirements.

Excess air in a furnace is a source of waste. It lowers the temperature of combustion by dilution; it retards heat absorption by decreasing the difference of temperature between gases and boiler contents; and it increases the quantity of the products of combustion so that the chimney gases carry off an undue amount of heat.

Wood shavings and sawdust should not be blown directly into a furnace; they may be blown into a cyclone on the roof from which they should be brought by gravity to about the feeding level but not entered directly into the furnace. From the bin they should be conveyed through a feed gate over the top of the furnace and dropped into the top of the furnace.

For proper combustion, ample space must be provided. If the combustion space is too small the rate of combustion will be limited. Arches are sometimes needed to reflect heat for drying and igniting the fuel.

In firing fine wood refuse it is well to observe the following rules:

1. Keep pit doors open at all times on boilers in service.

2. Control the steam pressure and main air supply with the boiler damper. Supply the necessary fuel to generate the quantity of steam required.

3. Admit air at all times over the fire by keeping the fire doors partly open. Regulate the opening of the

doors to prevent the discharge of dark smoke from the stack. The stack should be clear or a light haze should leave it. Planer shavings and dry fuel require wider fire-door opening than wet, fine fuel.

4. Fire often and in small quantities rather than in large quantities and less frequently.

5. Keep the fire thin in front and heavy in rear; top of rear fuel cones should be closer to arch than top of front fuel cones.

6. Fire in front should reach about four to six inches over the dead plate at the center of firing doors. It is better to have the grates slightly uncovered at the front than to have too much fuel charged.

7. The fire at the front should always appear bright and active. The firedoor opening should show bright when viewed from the firing floor; a dark door shows the fuel bed too heavy.

8. The fire should be heavy enough in the rear to prevent vicious flame coming through at the bridgewall.

9. With coarse, dry fuel the fire should slope at rear to slightly below the top of the bridgewall. With wet fuel it should be somewhat thinner. With fine, wet fuel the fire at the rear should slope to about half-way up the bridgewall.

10. Fire in the rear should be carried heavier for coarse and dry fuels and thinner for fine, wet fuels.

11. At no time entirely close the ashpit or firing doors on a boiler in service; use the boiler damper for main control of air supply.

Slag Reduces Efficiency of Boiler Tubes

SLAGGING Difficulties Being Reduced, which appeared in the November 1, 1927, issue, was interesting. We are having considerable trouble with slag depositing on the bottom row of tubes of our B. & W. boiler, so much so, that it is necessary to run fire off of our forced draft chain grate stoker at least every three weeks and then send men into the furnace to remove this slag.

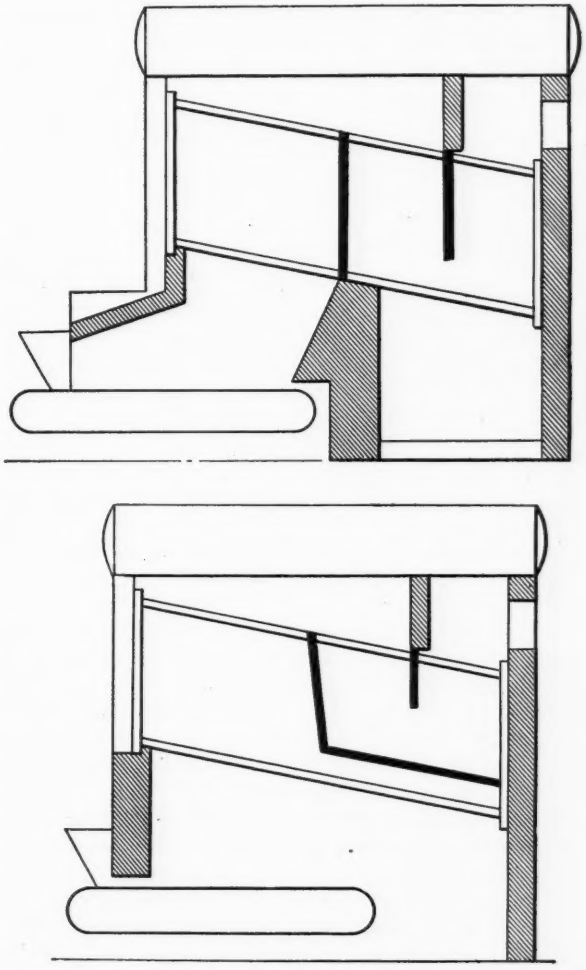
Newark, N. J. R. N. S.

A. Formation of slag on boiler tubes is caused by the fusion of ash with iron disulphide ($Fe S_2$) commonly known as iron pyrites when accompanied by sufficiently high temperature. When sulphur is one of the constituents of coal, it is usually found in the combination with iron just mentioned. Free sulphur in coal does not tend to form clinker. Slag or clinker formation may, therefore, be prevented by reducing the temperature of combustion or by any change in fuel.

With some coals, the melting point of the ash is as low as 1800 deg. F., while the ash in other coals may not melt under a temperature as high as 2800 deg., although few coals contain ash that will withstand a temperature approaching this latter figure. Furnace temperatures as high as 2200 deg. are frequently maintained under forced draft conditions. Temperatures beyond 2400 deg. are not common in practice. If your coal contains an ash that melts at a temperature below that of your furnace, the ash will melt if brought into that part of the furnace in which the high temperature occurs.

Temperature of combustion may be reduced in several ways. Exhaust steam injected under the grate is known to reduce clinker formation on the grate by reason of absorption of heat required to evaporate the water it contains and dissociate the steam itself. In a like manner exhaust steam may be used to reduce the temperature above the grate. Both of these methods are expedients, however, as they are wasteful of heat and should be used only for temporary relief. Cooling of furnace walls by means of either water on its way to the boiler or air used later in the process of combustion will also reduce this temperature. Both of these methods have the advantage that the heat is not wasted.

An effective way to reduce the temperature above the grate is to expose more of the boiler tubes to the radiant



CHANGE IN BAFFLING REDUCES TEMPERATURE IN FURNACE AND REDUCES SLAGGING TENDENCY

heat by changing the baffling as shown in illustration in which A probably represents your present condition and B the proposed change in baffling. It is possible also that, with the draft you are now using, your grate is set too close to the tubes. Changing your setting would probably not only relieve your trouble, but permit you to operate at a reduced draft.

By selecting a coal high in ash-fusion temperature and low in, if not free of, iron-disulphide, there would be little likelihood that slag would be formed.

IT IS EASIER and quicker to do a thing right the first time.

EDITORIAL COMMENT

Nature's Reminders

The failure of the St. Francis Dam near Los Angeles several days ago, resulting in the deaths of hundreds of people and in the destruction of millions of dollars worth of property, is a sad reminder of how puny man's efforts are against the unleashed forces of nature. In these days of marvelous achievements in engineering, when no project seems too big for men to tackle, when, one after another, obstacles of bygone years are overcome, we sometimes forget our insignificance and, with that characteristic conceit so typical of the human race, give expression to our mastery over nature's forces Here, we proclaim the harnessing of a mighty river; in another place, we boast of our control of infectious disease; again we sing of our conquest over land, sea and air. In all lines of endeavor, nature's forces respond to our will and we call upon the gods to witness it.

Nature, for the most part, is tolerant and humors us. Our dams impound great lakes of water which produce power and give us leisure; our knowledge of medicine keeps us healthy and adds years to our lives; our airships cover in a single hour distances that formerly took weeks and our ocean greyhounds make transatlantic travel a pleasure rather than hardship. Everything looks rosy.

And then, at a time when we are least wary, Nature shrugs her shoulders, so to speak—becomes fed up on our conceit, perhaps, and where a moment before stood a great dam of steel and stone, representing years of man's effort, there is a yawning gap and the waters we so carefully stored are sent swirling down valleys, carrying death and destruction before them. Or an influenza epidemic sweeps the world, destroying more humanity in one month than man is able in years of war and all our medical science is helpless against it. Again, a Shenandoah, queen of the air, leaves Lakehurst for a short inland voyage and a summer thunderstorm crumples it up like so much paper in less time than it takes to tell.

Man's Power over Nature! The angels must laugh. Man exists upon earth merely because Nature has so balanced conditions as to enable him to survive. This is well illustrated in the matter of temperature. It has been shown that if the variation in temperature over the surface of the earth exceeded seven per cent on the absolute scale of temperature for any considerable length of time, life could not exist. Now, seven per cent isn't much; yet, since life has existed upon this earth for millions of years, it is evident that in all these ages the temperature variation has been within that narrow range. There is little man could do to save himself if Nature should take a fancy to exceed the seven per cent variation.

Within the limits imposed by nature, however, man is an audacious little animal and while, perhaps, the angels sometimes snicker at his antics, at the same time he must command their admiration. The building of a dam or the cutting of a canal between two oceans or jumping over the Atlantic are not feats for a sloth, yet man does all these things with amazing success. True, his dams sometimes break; now and then a mountain slides into his canal and his airships frequently fail to make their hops, but he is never discouraged. Regardless of what caused the St. Francis dam to fail, before the waters have entirely receded, we find man at work building it up again.

Surely such perseverance cannot be lightly disregarded and so, when, with arms akimbo and with chest extended, man struts about confident in his power over nature, shouting it to the world, kindly Nature smiles and lets him have his way, one in a while, however, reminding him that he is not the main cheese in this universe. These reminders are not often gentle to man's way of thinking, but they serve to keep his feet on earth where they belong.

Power and the Industrial Growth

A thorough investigation into industrial production reveals a striking relation between the industrial use of power, the industrial output, and prosperity of a community. Two Englishmen in the book "Eclipse or Empire" report their studies of 24 industries and their summary shows that the electric power consumption per American worker is almost triple that of the British worker and that the average of the year's output was also three times as great. In itself, this ratio is important even without the concluding statement that "American wages are almost three times British wages."

The only possible conclusion is that the American wage scale and standard of living is made possible by the extensive use of power. Modern industries must of necessity be grouped in centers where an abundant and cheap supply of power is available. It is the only way they can increase the production per worker to a point to conform to the high wage standards maintained in this country.

Fortunately transmission problems have been successfully solved so that it is no longer necessary to concentrate industries in a small area. They can and are expanding to smaller centers where transportation and natural facilities are favorable, labor and living conditions are better and land values lower.

The Chicago district is one of the most favorable districts for new manufacturers to locate in and one public utility company serving a large portion of the northern Illinois territory has recently compiled some interesting statistics covering new industries which started operations in their territory. Comparing 1925

with 1927 shows an increase of 119 per cent for new industries for the year, the new power demands of these companies, based on contracted horsepower, increased 135 per cent. These figures, of course, do not include industries that were already established in the territory.

For many years, in fact since the birth of the power industry, the Chicago district has been one of the best served in the world from the standpoint of power. In this day when all communities are fighting so hard for new industries, it should be encouraging for the power industry to realize what an important part it plays in the industrial growth. Good salesmanship may have been directly responsible for the unusual industrial growth in the territory mentioned, but it is safe to say that power was the peg upon which the main arguments were hung.

Modern Industry Makes Great Use of Direct Current

In the mind of the average man, it has been our experience, the term electric power is intimately connected with the thought of alternating current. Just what alternating current is, however, he does not know. And as to why it alternates—oh! that's scientific stuff!

Even engineers, we find, have a sort of subconscious feeling that most of the electric power used today is in the form of alternating current. A visit to a number of representative modern industrial plants, however, quickly dispels this incorrect impression. As a matter of fact, it is estimated by trustworthy observers that 31 per cent of the electric power in industry is delivered by direct-current motors, which in numbers constitute 36 per cent of all motors in service. These figures do not include the motors used in traction work.

As pointed out recently by the General Electric Review, in commenting on one of its articles by Elihu Thomson, reviewing the development of the direct-current motor, it would require many pages to discuss the uses of direct-current motors. Most engineers, of course, when they stop to think about the subject, find that they are familiar with most of these uses. The one most often mentioned is that for driving equipment demanding adjustable speed. Much industrial process machinery is of this type. Whether the main power supply is purchased or generated, it is usually alternating current but eventually must be changed to direct current in the industrial system itself. Various types of controls for direct-current motors on hoists, blooming mills, elevators, material handling equipment and a host of other applications, not only give accurate control of adjustable speeds but also smooth off the "bumps" so that power is drawn steadily from the alternating current supply. Commutation has been mastered so that it no longer determines the choice between alternating and direct current for these applications. Thus we have the paradoxical situation that most of the direct-current applications occur where the initial power supply is alternating current.

Then, too, the engineer who gets Australia every night on his 10-tube Super-Complex knows that direct current is the one thing that is indispensable to the operation of this equipment. The fundamental principle of the vacuum tube itself, which has opened up a new world to both scientist and layman, depends on impressing a constant potential (direct-current voltage) on certain parts of the apparatus.

Finally, the use of direct current for long-distance power transmission is by no means the dream of a visionary. The principal reason why it is now more economical to generate our primary power as alternating current is that the alternator lends itself better to direct connection with a turbine at a speed that is efficient for the turbine. Assume, however, that we then change the alternating to direct current for power transmission. We would then eliminate from the transmission line inductance, reaction, capacity and many of the other factors that make the electrical engineer's hair turn gray, and our principal loss would be the I^2R loss. Up to the present time, the principal reason for the transmission of power as alternating current has been that it permits the use of the transformer, an apparatus having no moving parts and of comparatively small size as compared to a motor generator or rotary converter. Then, too, circuit breaker operation is different with the two types of current. Experiments are now being carried on, however, in the transformation of direct current, and have resulted in much information of value.

It is evident, therefore, that the power plant engineer should by no means neglect to keep himself fully informed on the subject of modern direct-current machinery. It is a fascinating subject in itself and forms an extremely important factor in present-day industry.

Results from Proper Public Relations

Speaking before the Iowa Power Conference recently on the subject of "The Year's Record," Joe Carmichael, Director of the Iowa Public Utility Information Bureau, drew attention to three things, a steady continuance of the tendency toward consolidations, resulting in more and more interconnection, a higher standard of construction in transmission and distribution systems and a more helpful attitude on the part of the central station companies toward the farm electrification problem.

Practically all the public utility power generated in the state of Iowa is produced by 13 companies or groups of companies, who own 96 per cent of the generating capacity. The remaining 4 per cent is scattered among 55 municipal plants. 99.7 per cent of the urban population of the state is located in cities and towns that have electric service and the energy generated per capita is about 583 kw-hr. per year, placing Iowa 23rd among the states of the Union in this respect. Iowa is therefore about an average state and a study of its progress may be considered more or less as a trend of the industry as a whole.

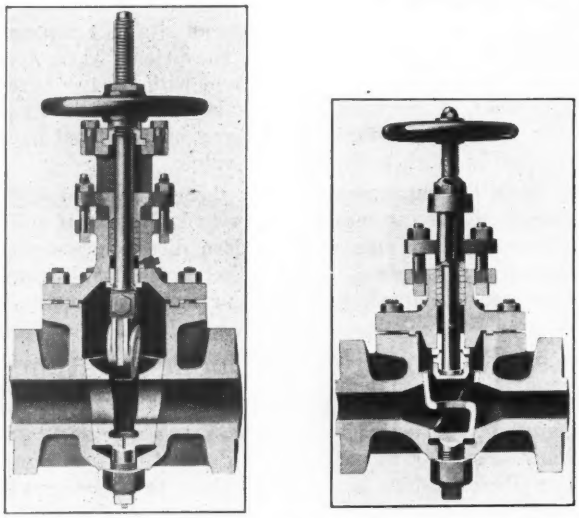
Probably no state in the union has more drastic or hampering public utility regulation than Iowa, yet there are few states where the public relations of the central station companies are in better shape and so well handled.

Iowa is a successful example of the results achieved by cooperation and education. More states could to advantage adopt the policy of close cooperation and strict attention to public relations adopted by that state.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Wellman Supertest Gate and Globe Valve

USERS OF VALVES for high pressures and high temperature purposes will be interested in a new type of valve developed by The Wellman-Seaver-Morgan



LEFT—WELLMAN SUPERTEST GATE VALVE, SHOWING REMOVABLE CAGE CONSTRUCTION. RIGHT—GLOBE VALVE DESIGNED ON SAME PRINCIPLES

Co., Cleveland, Ohio, which is being marketed under the trade-name of Wellman Supertest Valve.

In the Wellman supertest valve the valve seats are an integral part of a slightly tapered removable valve-cage; the valve cage itself has an external take-up adjustment, designed to compensate for the expansion or contraction and to prevent leakage between the walls of the cage and the main valve body.

The valve cage may be utilized to shut off the flow through the valve while repairs or adjustments are being made, eliminating the necessity of taking the entire valve body out of the line.

The valve cage has guides corresponding with slots in the wedge-type gate, to control the path of travel of the gate and prevent rubbing of the surfaces of the gate and seat. This valve cage is circular in cross-section to permit it to be rotated into position or given a quarter turn to shut off the flow during repairs. The valve seats are flat to allow closing of the valve under high pressures, at the same same allowing the valve to be easily opened. Gate faces are removable and may be replaced when worn or adjusted when desired. A solid wedge can be furnished on request.

The valve is designed so that the valve surfaces are released from the seat at the slightest movement of the valve stem on account of the wedge shape with its center guides which is intended to eliminate sliding action and to avoid wear and the wedging of the valve faces against the valve seats.

These valves conform to dimensions which have been approved by the American Society of Mechanical Engineers Standards Committee for steel pipe flanges and flanged fittings, while the materials conform to the requirements of the American Society for Testing Materials. The one piece valve bodies, as well as the bonnets, are of forged steel. The cages, gates, gate bolts, stems, bushings and gate seats are of stainless steel.

The valves are made in both the gate and globe types, as shown. Gate valves are of the rising stem type designed for straightway flow. Body and cover flanges have tongue and groove joints for soft steel corrugated gaskets. Globe valves have forged steel bodies and bonnets with either inside screw, or outside screw and yoke. Globe valves are made in ¾, 1, 1½, 2 and 3-in. sizes. Gate valves are made in sizes from 1 to 6 in. and larger sizes up to 24 in. will also be supplied.

G-R Tubeflo Section

FOR HANDLING dirty or corrosive liquids and gases, an interesting type of heat exchanger and cooler, as shown herewith, has recently been developed. This apparatus, called the G-R Tubeflo Section, is made

FIG. 1. INDIVIDUAL PARTS OF G-R TUBEFLO SECTION

entirely of semi-steel in order to withstand corrosion, and the fluid passages are straight, smooth, cored holes, designed to be readily cleaned. The main portion of the section consists of a number of body pieces bolted together to make up the required length for a desired cooling effect. At one end of the section is bolted a stationary head which contains the inlet and outlet connections, together with the necessary partitions for directing the flow of the mediums through the four chambers of the body pieces. At the opposite end of the section, a floating bonnet forms a crossover connection between the passages. The stationary head is also provided with a removable cover to permit easy inspection of the chambers and accessibility for cleaning.

Various parts of which the G-R Tubeflo Section is

built up are all standard and interchangeable, to reduce the cost of these sections and also to make them exceedingly flexible in capacity and cooling effect. Sections are readily made longer or shorter by changing the number of body pieces; they can be installed in stacks one over another; and any number of stacks can be used in parallel, depending upon the duty which they are to handle. When arranged in stacks, the stationary heads of the sections are bolted together and the body

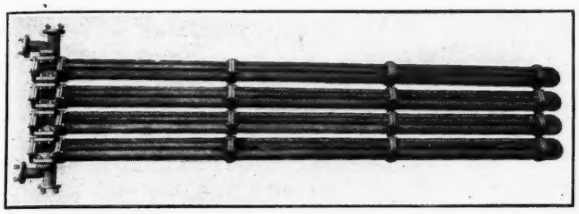
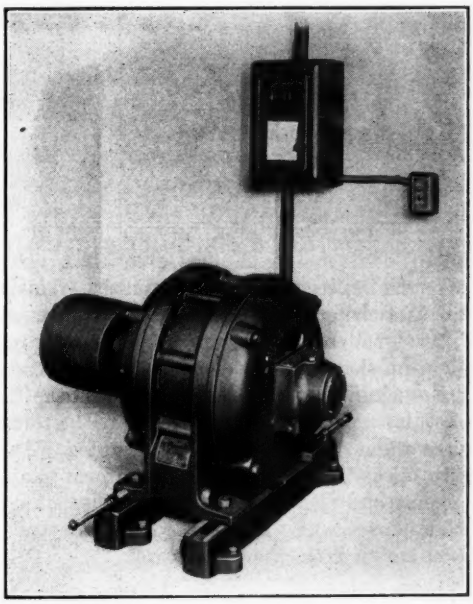


FIG. 2. STACK OF SECTIONS ASSEMBLED

pieces of each section are held in proper position by lugs which permit free movement for expansion and contraction. The G-R Tubeflo section is made by The Griscom-Russell Co., New York.

Line Start Induction Motors

FOR STARTING on full line voltage, a line of squirrel cage induction motors is being placed on the market by Allis-Chalmers Manufacturing Co., Milwaukee, Wis. These motors are normal torque, high



NEW TYPE ARX LINE START MOTOR WITH STARTER BOX

reactance machines, designed so they will not draw starting current in excess of the limits recommended by the Electrical Apparatus Committee of the National Electric Light Association. They are built in ratings of 7½ to 30 hp., 600 to 3600 r.p.m., low voltage, and are available with either sleeve or roller bearings. Features of Allis-Chalmers construction as employed in squirrel cage motors are maintained in this new line. A magnetic switch with push button control is the only starting equipment required.

Improvements on Riley Atrita

DURING THE PAST year, developments have been made on the different sizes of Riley Atrita unit pulverizers to give greater reliability, smoother performance and lower maintenance. The majority of these

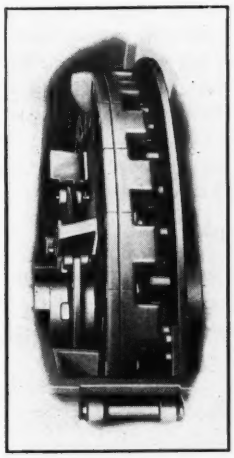


FIG. 1. PULVERIZING ELEMENTS AND NEW FIRST EFFECT HAMMER DESIGN

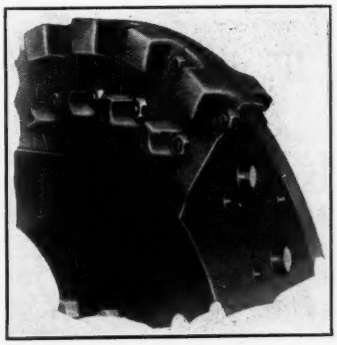


FIG. 2. ROTOR WITH SOME OF UNIT CASTINGS REMOVED

developments have been in the design and construction of pulverizing elements. It will be remembered that originally the pulverizing elements of the Riley Atrita unit pulverizer consisted of small oval shaped pegs. The next step in the development was the use of larger round pegs. This increase in the size of the pegs increased the life over the original design several times. With the peg type of construction it was necessary to install wearing plates on the rotor to take care of any tendency of the rotor to wear.

The present construction, Figs. 1 and 2, consists of small cast segments which are installed on the rotor. The faces of these castings act as the wearing plate so that there is no possibility of the rotor itself wearing. The peg section of the unit casting is many times larger than the two and one-half inch pegs previously used. The castings are extremely rugged. Greater fineness of pulverization has also been obtained, it is stated, as well as smoother operation.

It is claimed that the greatest feature of the new construction, however, is the low maintenance which has resulted from its use. The life of the pulverizing elements has been increased from four to seven times that of the peg construction.

Figure 1 shows the pulverizing elements as well as the new first effect hammer design. Figure 2 shows the rotor with some of the unit castings removed; it also illustrates the method of holding the unit castings to the rotor. The unit castings are made with a pressed steel ferrule cast into them. This ferrule fits into a bored hole in the rotor. The use of the ferrule is to

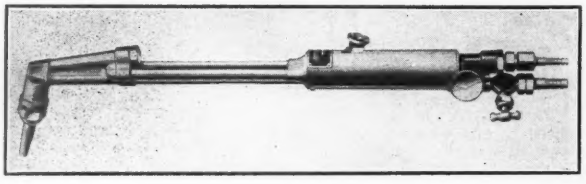
eliminate the necessity of close machining at this point. That section of the unit casting takes all of the centrifugal strain so that it is only necessary to hold the castings together. This is accomplished by bolts, as shown in the photograph.

The method of supplying hot air to the Riley Atrita unit pulverizer has also been redesigned to assure more effective use of hot air. This is particularly necessary when coal with a high moisture content is being used.

The coils used in the magnetic separator have been entirely enclosed in order to eliminate the possibility of fuse wire and fine coal getting into the separator and gradually causing wearing of the coils and consequently short-circuiting. This new design has been in use for over a year on all of the machines using an integral separator.

Type C-14 Oxweld Cutting Blowpipe

KNOWN AS Type C-14, a new cutting blowpipe, designed to prevent backfire even under the most severe operating conditions, has been added to the line



ABOVE—TYPE C-14 CUTTING BLOWPIPE HAS FORGED HEAD AND REAR BODY

NEW TRUCK FOR WELDING EQUIPMENT HAS 24-IN. WHEELS FOR EASE OF HANDLING

of the Oxweld Acetylene Co., 30 East 42nd St., New York.

This blowpipe uses the same nozzles as the type C-2, which it resembles, although several improvements in design have been made. The three gas tubes are straight, having no bends either outside or inside the handle. The cutting valve is of the same design as has been used on the type C-6 and is now used on all hand cutting blowpipes of the same make.

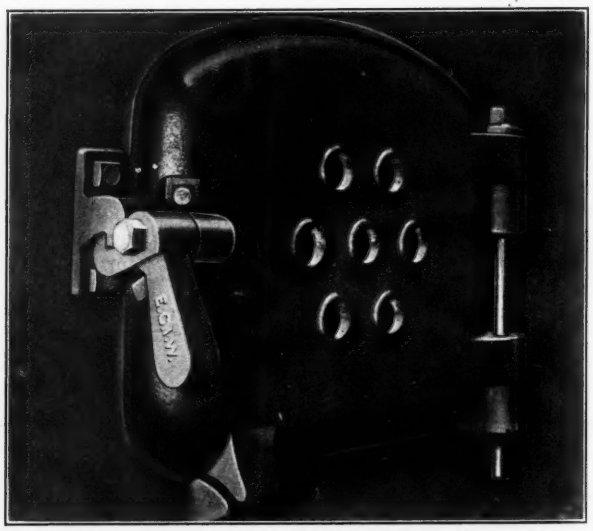
Besides the needle valve bodies, both the head and the rear body of the type C-14 are also pressure forgings, instead of castings, to give better appearance, increased durability and lessened weight.

Interchangeable nozzles are provided so that the blowpipe may be used with either medium or low pressure acetylene. To use low pressure nozzle with a medium pressure acetylene supply, the regulator should be adjusted to give a flame showing an excess acetylene cone not more than 1 in. long when the acetylene valve on the blowpipe is wide open. The acetylene valve should then be adjusted to obtain the neutral flame.

A new type of two-wheel truck for oxy-acetylene equipment has also been put on the market by this company. The new truck is equipped with 24-in. steel wheels to increase ease of handling. The hub is bored to fit the cold-rolled steel axle and a grease cup is provided for lubrication in case the truck may be hauled long distances at fairly high speed behind a motor truck.

Improved Safety Latch for Steam Boilers

ERIE CITY IRON WORKS, Erie, Pa., has recently placed on the market an improved safety latch for firing doors of steam boilers, as shown in the accompanying illustration. A recent ruling by the State of



IMPROVED SAFETY LATCH FOR BOILER FIRING DOORS

Ohio gave the impetus to this development. This ruling provides that firing doors of the inward opening type on all steam boilers carrying pressures in excess of 15 lb. per sq. in. shall be provided with devices to prevent them from being blown open by pressure on the furnace side. It also provides that the latch or bolt must be dependent upon gravity or counterweighted. The new Erie City safety latch is designed to conform to all these requirements and also to those of any other state boiler inspection department. The method of operation of the latch is apparent from the photograph.

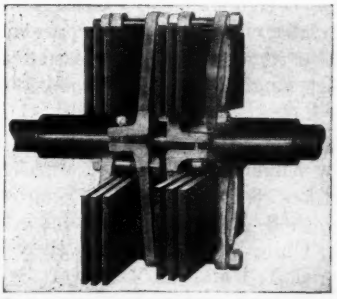
UNITED GAS IMPROVEMENT CO., Philadelphia, Pa., in 1927 earned net profits of $12,934,457.26, according to the profit and loss statement of the company. This is 12.56 per cent on the average capital stock outstanding during the year and represents an increase in net profits of $3,591,843.27.

Capital stock dividends paid during the year amounted to $8,144,072.00, an increase of $1,627,184.00. The balance to undivided profit account was $4,790,385.26, an increase of $1,964,659.27.

New Hollow Square Bus Support

WESTINGHOUSE Electric and Manufacturing Co. has developed a new line of bus-bar supports known as the modified hollow square type. These supports consist of heat-treated aluminum alloy clamps which are insulated from the standard 1¼-in. pipe of the mounting support by means of high-grade micarta tubes. The bus support is designed for 4-in. by ¼-in. bus-bars and for a maximum of 4000 v. a.c. or d.c.

These supports may be adjusted to carry 1 or 12 bars. This feature allows the bus to be tapered as feeders are tapped off or allows the easy installation of additional bus copper to provide for an increasing load. The hollow square arrangement of bars will minimize the influence of both skin effect and proximity effect and



NEW HOLLOW SQUARE BUS SUPPORT

will allow the copper to be used at its maximum efficiency. The modified hollow square bus-bar supports are particularly adapted to heavy low-voltage bus construction.

News Notes

UNDER THE direction of the Engineering Extension Dept. and the School of Mechanical Engineering and the School of Chemical Engineering of Purdue University, the Indiana Fuel Conference is to be held at Purdue University, Lafayette, Ind., April 5-6, 1928. Tentative program recently announced shows that there will be discussion of such subjects as fuel resources of Indiana, fuel and power as affecting progress, fuel research problems, burning Indiana coal, coal storage, smoke elimination and coal marketing. Papers on these subjects will be presented by authorities on Indiana fuel resources.

THE LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the retention of A. M. MacFarland as general sales and development engineer. Mr. MacFarland will devote his efforts to the development and special application of automatic carbon arc welding, with headquarters at Cleveland.

WHEN THE Cutter Electrical and Manufacturing Co. of Philadelphia recently decided to change its name to the I-T-E Circuit Breaker Co., it was felt that there must be a significant reason for the change. Philip C. Gunion, sales manager of this company, said in a recent interview: "The primary reason for changing our name was that we were constantly being confused with two other electrical manufacturers of similar name, one of which is owned by a competitive organization. As there has been no Mr. Cutter connected with our company for over 25 yr., there was no reason not to change. Using the product name as a company name gives us a fully descriptive name that cannot be confused with the name of any other company. The policies, personnel and products of the I-T-E Circuit Breaker Co. are identical with those of the old company—nothing has been changed except the name."

UPON APPLICATION by the Paige & Jones Chemical Co., Inc., a license has been granted to it by the Permutit Co. to manufacture and sell industrial zeolite water softeners of the upflow type. This agreement, which became effective March 15, 1928, further provides that customers of the Paige & Jones Chemical Co. who bought zeolite water softeners from it may use such apparatus lawfully and in perfect safety. The Permutit Co. also granted to Paige & Jones Chemical Co. a license for use of the U. S. Patents 1,348,977 and 1,455,363, both relating to Greensand Zeolite (Glauconite).

THE INTERSTATE POWER CO. has begun installation of a $200,000 gas plant in Clinton, Iowa, one of the first of its kind in the state, and incorporating the latest methods of production of gas from coal, providing the community with greatly increased production capacity in anticipation of extension of gas for home, manufacturing and industrial purposes. The United Gas Improvement Co. of Philadelphia, which has contract for the work, will utilize vertical retorts for the plant, the gas coal being elevated 60 ft., charged into the top of the retorts and discharged at the ground level as coke. The plant will have daily capacity of 750,000 cu. ft. of gas with provision for additions which will bring the output to 1,000,000 cu. ft.; 48 t. of coal will be carbonized daily. The unit is expected to be ready in November.

ON THE CEDAR RIVER, near Rochester, Cedar County, Iowa, a $2,000,000 hydro-electric power plant is projected by the Iowa Railway and Light Corp., which has filed application for permission to erect and operate a dam and hydro-electric station expected to develop 23,000,000 kw-hr. annually. Isaac B. Smith, Cedar Rapids, president of the corporation, has announced that the project will not be undertaken for 3 yr., the application just made being to protect its interests in the dam site acquired some years ago. A concrete dam with its permanent crest 22 ft. above the normal water level of the lake, which will be created covering approximately 2250 acres, will be supplied with a spillway, parallel to the river channel to protect it against flood tides. The power house along the spillway will be 50 by 140 ft. with a concrete and brick superstructure. Five hydro-electric units of 1400 kv.a. each will be installed.

U. G. I. CONTRACTING CO. of Philadelphia, Pa., has placed an order with the Westinghouse Electric and Manufacturing Co. for a 30,000-kw. turbine generator unit and its necessary condensing equipment. The new apparatus will be installed at the New Braunfels Station, New Braunfels, Texas, of the San Antonio Public Service Co. The turbine will be of the single-cylinder, impulse reaction type and will operate at 1800 r.p.m. Steam will be supplied to the throttle at 385 lb. gage, 255 deg.

F. superheat and will exhaust at a pressure of 1½ in. mercury absolute. The generator will have a rating of 30,000 kw., 90 per cent power factor, producing 3-phase, 60-cycle current at 13,800 v. A direct connected exciter will be furnished. The condensing apparatus to be furnished will include a 37,500-sq. ft. radial flow surface condenser designed to condense approximately 250,000 lb. of steam per hour and maintain a vacuum of 28½ in. of mercury.

NATIONAL PIPE BENDING Co., New Haven, Conn., has appointed J. Harold Flynn to its engineering staff.

YEOMANS BROTHERS Co., Chicago, Ill., has appointed H. F. Kircher & Co., Lehman Bldg., Peoria, Ill., to represent it in the central part of Illinois.

MAGNETIC MFG. Co., Milwaukee, Wis., has appointed T. F. Scannell, 502 Ambassador Bldg., St. Louis, Mo., as its representative.

ALLIS-CHALMERS MFG. Co., Milwaukee, Wis., announces that E. D. Hill of that company will be located at 42 Church St., New Haven, Conn., to give service in connection with the company's products. Sales will be under the direction of A. F. Rolf, Manager of Allis-Chalmers New York office, 50 Church Street.

E. H. ROLLINS & SONS, Chicago, Ill., is offering for sale the 5 per cent Secured Gold Debentures of the National Public Service Corp., maturing in 1978, priced at 93½ and accrued interest, to yield over 5.35 per cent. This corporation controls Jersey Central Power & Light Co., Municipal Service Co., Virginia Public Service Co., Eastern Shore Public Service Co., Florida West Coast Ice Company and Tide Water Power Co.

ON MARCH 15, 1928, the branch sales office and factory of the Carbon Sales Division of National Carbon Co., Inc., moved from its former location at 357 W. 36th St., New York City, to new and larger quarters at the company's plant at Fourteenth and Henderson Sts., Jersey City, N. J.

ERIE CITY IRON WORKS, Erie, Pa., has established a district sales office at 122 S. Michigan Ave., Chicago, Ill., with Charles B. Acheson as district manager, J. R. LeVally as special engineer and D. F. Lytle as sales representative. E. J. Clerget is in charge of a sub-office of this district at 511 Traction Terminal Bldg., Indianapolis, Ind.

TO CONDUCT the comprehensive program of the Second National Meeting of the Fuels Division, American Society of Mechanical Engineers, to be held during the week of September 17 in Cleveland, Ohio, a special committee has been appointed. This consists of Col. Elliott H. Whitlock, chairman, P. V. Fraser, Theodore Maynz, John Wolff, F. H. Vose, H. K. Kugel. The technical program will be under the guidance of the chairman of the Fuels Division, Victor J. Azbe.

AS A RESULT of a survey of the Tennessee River and its tributaries made by the chief of engineers and the Board of Engineers for Rivers and Harbors of the United States Government, a partial report has been submitted to the Secretary of War. Among other matters, this report refers to the investigation of the Cove Creek dam site and states that construction of a dam, power plant and navigation facilities at that point would cost $37,000,000, but for proper economic development of power it would be better to combine the Cove Creek reservoir with the Clinton, Melton Hill and Kingston dams at an additional cost of $24,000,000.

Studies indicate that power projects on the Tennessee may be regulated with much less cost by storage than by steam auxiliaries and that storage is much needed for the development of economic power projects on the Tennessee River. The studies indicate that the Cove Creek project and other storage projects should be operated for the regulation of stream flow and power of the Tennessee River system rather than for the benefit of any individual project. The report states that additional installation of generating capacity at Dam No. 2, Muscle Shoals, is not justified under present conditions. Although the commercial feasibility of the entire tentative project cannot be determined at this time, the data may be of great value to anyone interested in power development of the Tennessee Basin. Since the number of such persons is comparatively limited, all the material will not be printed, but copies of maps, charts and diagrams and other items may be purchased from the office of the District Engineer, 40 Municipal Bldg., Chattanooga, Tenn.

IDEAL COMMUTATOR DRESSER Co., Sycamore, Ill., has opened a New England office at 182 Purchase St., Boston, Mass. It has also appointed the following sales representatives: C. B. Keck, 1565 Rydalmount Rd., Cleveland Heights, Ohio; F. D. Lawrence Electric Co., Cincinnati, Ohio; O. T. Hall, 432 N. Calvert St., Baltimore, Md.; C. A. Brewer, New Haven, Conn.; DeMoss-Fox & Co., 320 Beaubien St., Detroit, Mich.

SHAW CRANE-PUTNAM MACHINE CO., INC., owned by Manning, Maxwell & Moore, Inc., announces the purchase of the Lamb & Nash line of sheet metal machines. These will now be made at the Putnam works of the company at Fitchburgh, Mass.

THE COLONIAL IRON WORKS Co., Cleveland, Ohio, announces that Eugene W. Stern, consulting civil engineer of New York City, is now vice president of the company, acting in an advisory capacity and assisting in directing the general policy.

THE PRODUCE TERMINAL COLD STORAGE Co., Chicago, Ill., care of Henschien & McLaren, 1637 Prairie Avenue, architects, has asked bids on a contract for its proposed 10-story cold storage and refrigerating building at Throop St. and 15th Pl., Chicago.

THE CHAMPION FIBRE Co., Canton, N. C., has approved plans for an addition to its steam power plant. The boilers will have a capacity of 300,000 lb. of steam per hr. at 450 lb. pressure and will be fired by pulverized coal. A 4000-kw. Westinghouse turbo-generator will be installed.

SHELDON, Iowa, Electric Light Co. has awarded contract for the construction of a concrete and brick power plant, to cost $150,000, and will install two 600-hp. oil burning engines for motive power.

LEWIS BUCKLEY STILLWELL of New York has been reelected chairman of the Engineering Foundation, the research organization of the national engineering societies. Mr. Stillwell, who enters upon his fourth term, is past president of the American Institute of Electrical Engineers and the American Institute of Consulting

Engineers. He is a native of Pennsylvania, a graduate of Lehigh and a life trustee of Princeton. Wesleyan University bestowed upon him the degree of doctor of science.

He is a member of the American Society of Civil Engineers, the Institution of Electrical Engineers of Great Britain, the American Engineering Council, the National Academy of Sciences, the Royal Society of Arts in Great Britain, the American Philosophical Society, and the Franklin Institute.

The Foundation re-elected the following vice chairmen: Arthur D. Little, president of the Arthur D. Little Laboratories, Cambridge, Mass., and inventor of many chemical processes; George A. Orrok, a member of the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers. Robert Ridgway of the American Society of Civil Engineers, and J. V. N. Dorr of the American Institute of Mining and Metallurgical Engineers were chosen additional members of the Executive Committee. Other officers were again named as follows: Director and secretary, Alfred D. Flinn; treasurer, Jacob S. Langthorn; assistant treasurer, Henry A. Lardner. A gift of $10,000 to the Foundation Endowment by the Central Hudson Gas and Electric Corp. has been announced.

GIFFELS, HAMILTON & WEEBER, Engineers, Kelsey Office Bldg., Grand Rapids, Mich., announces that this is the new firm name to succeed the old one of Burd, Giffels & Hamilton, with offices at the same address.

MORSE CHAIN CO., Ithaca, N. Y., has appointed T. M. Manley, who has been with the company for 20 yr., as manager of a large district including northern New York, western New England and northeastern Pennsylvania, with headquarters at Ithaca.

BOILER ENGINEERING CO., 931 Federal Trust Bldg., Newark, N. J., has appointed the Pennock-McGee Co., 1430 Bleury St., Montreal, as its representative. It has also appointed G. Taylor Swarts as its representative in the Pittsburgh district, with office at 2201 Oliver Bldg., Pittsburgh, Pa.

PEOPLES' LIGHT CO., Davenport, Iowa, has renewed its articles of incorporation for another 20-yr. period, amending its charter to specify $2,500,000 capital, divided into 25,000 shares of $100 par value each, of which 21,250 shares have been issued.

CONSTRUCTION of a 132,000-v. steel tower transmission line 59 mi. long to supply additional power in northeastern Ohio will be started by the Cleveland Electric Illuminating Co., Cleveland, Ohio, about April 1, according to a recent announcement.

GROSS EARNINGS of the Central Illinois Public Service Co. last year were $13,444,713.22, an increase of $700,635.63 over the previous period, according to reports submitted at the annual meeting of stockholders in Springfield, Ill.

SIOUX CITY, Iowa, Gas and Electric Co. and its railway subsidiary, the Sioux City Service Co., paid the city $49,037.26 through its first department and $16,054.42 through its traction lines division last year, according to annual report of W. J. Bertke, president of the utilities.

Books and Catalogs

ENGINEERING OF POWER PLANTS, by Robert H. Fernald and George A. Orrok. Third edition. McGraw-Hill Book Co., 370 Seventh Ave., New York, N. Y.; price, $5.50.

To keep pace with power plant development, the authors have revised the book and incorporated a great deal of new data, bringing the subject matter, particularly tests of specific units and stations, up to the end of the year 1927. Besides covering every phase of the steam power plant from an operating, designing and economic standpoint, the book contains shorter chapters on specific requirements of district heating, office buildings, locomotive requirements, internal combustion engines, producer gas, compressed air, refrigerating machinery and hydraulic power. Although it is written primarily as a text book, the vast amount of tabulated data on costs and operating results makes the book of unusual value for reference work for practically all classes of engineers.

"MECHANICAL WORLD" Electrical Pocket Book, 1928; cloth, 6¼ by 4, 400 pages, 134 illustrations. Emmott & Co., Ltd., 65 King St., Manchester, England. Price, about 48 cents.

This is an excellent little volume which contains information and data useful to anybody engaged in electrical work. This year a new section devoted to electrical calculations has been added in which the method of attacking various problems is set out in detail, various examples being given to elucidate the methods employed.

Another section deals with estimating for wiremen and gives many hints and suggestions which will be of service to those preparing estimates for electrical work. A lengthy section is devoted to the use of electricity in textile mills, and in this many relative data are given, while systems of driving are discussed and notes given on the types of motors employed, power required for various operations, etc. Various new tables are given, notably those on power consumption of electrical appliances; Current taken by electric motors; Lead accumulators, etc. A new table of insulated copper conductors is also included.

ELECTRIC CONTROL GEAR AND INDUSTRIAL ELECTRIFICATION. By William Wilson. Cloth, 6 by 9, 362 pages, 216 illustrations; first edition, Oxford University Press, American Branch, New York, N. Y. Price, $8.50.

In this book it has been the aim of the authors to supply the wants of as many classes of engineers who may want information on this subject, as possible. The book is designed primarily for reference; each chapter as far as possible is complete in itself and may be read and understood independently of those that come before and after.

Beginning with a brief history of electric drive, in the introduction, two chapters are devoted to the theory of direct and alternating current motors. These are followed by chapters on various methods of control and types of resistors and related equipment. Perhaps the best way of giving an idea of what the volume contains is to list the more important chapter headings. These, following the introductory chapters, are as follows: Manual starters and controllers; Resistance control; multiple voltage and series parallel control; The starting

of squirrel-cage and synchronous motors; Solid resistors; Liquid rheostats; Contactors; Contactor coils, contacts and other details; Contactor interlocks, relays and switches; Motor generator control systems; Electric lifts; Electric operation of steelworks; Control of furnace and mine hoists, etc.; Electric cranes and gantries; Machine tool control; Miscellaneous control gear and Conclusion.

The foregoing are only the most important chapter titles. The author seems to have covered the subject rather exhaustively and the book should be of interest to anybody having to do with electric control.

MECHANICAL DRAFTING HANDBOOK, by Frank R. Kepler; 127 pages, paper cover; The Bruce Publishing Co., 354 Milwaukee St., Milwaukee, Wis.; price, 90 cents.

A handy little book intended to provide students and mechanical draftsmen with a collection of essential usages, standards, conventions and tables based upon modern practice. Part I deals with the fundamentals of drawing and lettering, care of instruments, tracing, steps in penciling, working drawings, etc. Part II treats the subject of standards and conventions. Sample drawings are provided. Part III concerns itself with screws and nuts, tap drills, etc. A helpful appendix dealing with geometrical construction is given.

STEAM TURBINES. By Edwin F. Church, Jr., Professor of Mechanical Engineering, Polytechnic Institute, Brooklyn. 265 pages with index. Price, $3.00, McGraw-Hill Book Co., 370 Seventh Ave., New York, N. Y.

A concise text on steam turbines, opening with a chapter on the general form and principal characteristics of different type turbines and explaining the terms to be used. Attention thereafter is centered on the application of thermodynamic principals and calculations of flow of steam through nozzles and blade passages of the turbines, changes in heat, pressure and volume and the various factors effecting efficiency.

Throughout the book the subject is handled in a brief, clear and logical manner. Although written primarily as a text book, it will be a valuable addition to the library of engineers who have a working knowledge of ordinary steam cycles, steam tables and charts.

NEMA HANDBOOK OF SUPPLY STANDARDS; size, 6 by 9, paper, 231 pages, 125 illustrations; National Electrical Manufacturers Association, 420 Lexington Ave., New York. Price, $3.50.

A guide book on the design, manufacture and installation of electrical supply equipment. It contains standards endorsed by 189 manufacturers of the supply division of the N. E. M. A. on air circuit breakers, attachment plugs, fuses, cutout bases, knife and enclosed switches, lamp receptacles and sockets, laminated phenolic products, metal molding, non-metallic flexible conduit, outlet boxes, overhead trolley line materials, panelboard and distribution boards, signalling apparatus and snap switches.

APPLIED MAGNETISM, by T. F. Wall, First edition, cloth, 7½ by 10 in., 262 pages, 146 illustrations. D. Van Nostrand Co., Inc., 8 Warren St., New York, N. Y., 1927. Price, $8.00.

There has been a distinct need for an up-to-date work on magnetism and this book, it seems, goes far toward satisfying that need. Considering the importance of magnetism in electrical engineering, it is strange that no more has been published on this subject. The results obtained with the recently introduced alloys known as permalloy indicate the possibilities of further studies in magnetism. It was with the view of presenting a reasonably complete survey of this branch of electrical engineering that this book was written.

In the first part the principles of applied magnetism are considered and a brief account of the electron theory of magnetism is included. In the second part of the book various methods of magnetic testing are considered. While it is impossible in a book of this kind to deal with all the available methods of testing, a reasonably representative selection has been made so as to include the tests which are likely to be most generally reliable and useful in practice.

PURPOSE AND DEVELOPMENT of the National Electrical Code and its relation to electrical manufacturers is outlined in some detail in a recent publication issued by National Electrical Manufacturers Association. The booklet is designated as "The National Electrical Code, Its Purpose and Development."

The code is a collection of rules and regulations governing choice and installation of electric wiring, materials, apparatus and supplies and the procedure for making changes in the code, together with important data about Underwriters' Laboratories, addition of "New Materials" and "Field" changes in the code are here outlined for the first time under one cover. The rapid growth in the use of electricity and the spread of radio has caused a flood of inquiries to the Association office, which, officials of N. E. M. A. believe, will be largely answered in this publication. The book is not a compilation of the rules themselves, but gives clearly the methods by which they are revised and kept modern in order to keep pace with improvements and changes in the art of wiring and using electrical equipment and devices.

FORTY ELEMENTARY LESSONS IN ELECTRICITY. By E. H. Thomas, Utility Users Magazine, 2224 Second Ave., Seattle, Wash.; 48 pages; price, 75c prepaid.

A simple and comprehensive text book especially designed for school work and for the use of those who desire to learn the fundamentals and underlying principles of electrical science. The material has been put in untechnical language for the use of those who know nothing at all about the subject, but desire to begin its study.

PREFERRED NUMBERS, informally approved and recommended by the American Engineering Standards Committee, has just been published and is being distributed for the purpose of trial and criticism. The purpose of this system is to eliminate economic loss involved in the haphazard gradations of size that characterize many of our common commodities. The fundamental elements lie in the proposal to arrange standard size series so that each succeeding member in the series shall be larger than the preceding size; not by a definite amount, but by a fixed percentage. These standards are given in the A. E. S. C. publication Z 17-1927, dated June, 1927, priced at 20 cents each. They are obtainable from the American Engineering Standards Committee, 29 W. 39th St., New York, N. Y.

WALWORTH CO., Boston, Mass., has just issued two folders containing tables of standards for cast iron pipe flanges and flanged fittings for 125 lb. and 250 lb.,

developed under the procedure of the American Engineering Standards Committee, which are effective now. All Walworth series 150 steel flange dimensions will follow the new 125 lb. cast iron flange drillings, while series 300 steel flange dimensions will follow the new 250 lb. cast iron standards. Three sizes of the new flanges will not bolt to the old flanges. These are 3½ in.—125 lb., 2 in.—250 lb., 2½ in.—250 lb. The tables illustrate the new conditions and will be sent on request to users of fittings.

WORTHINGTON PUMP HANDBOOK. Written by Worthington engineers, published by the Worthington Pump & Machinery Corporation, 1250 pages. Price, $1.00.

Written by engineers of the company, each department contributing material pertaining to that branch of pump engineering, the book is authoritative and practical, valuable in a reference library of any engineer, student or user of mechanical equipment. The contents are divided up into nine sections, entitled General Theory and Uses; Centrifugal Pumps; Power Pumps; Deepwell Pumps; Power for Pump Drives; Direct Acting Steam Pumps; Installing and Operating Pumping Machinery; Pumping in the Petroleum Industry; and a tabular section containing tables and formulas for hydraulic calculations.

TIMKEN ENGINEERING JOURNAL, published by the Timken Roller Bearing Co., Canton, Ohio, consists of a group of the company's bulletins, enclosed in a card board cover, containing information for designers relative to duty of bearings, load calculations and their selection, mounting of Timken Bearings, lubrication and other information of value. Tables of dimensions are given and details of the bearings that should prove of great value in laying out machinery.

AEROFIN CORP., 750 Frelinghuysen Ave., Newark, N. J., has issued bulletin No. 7, superseding all prior bulletins, covering low pressure Aerofin for pressures of 2 to 50 lb. This is a 62-page book illustrated in color, containing not only description of the Aerofin but also many valuable tabulations of sizes, capacities, steam conditions and many diagrams of connections. The company is also issuing bulletin H.P.-1 on the high pressure Aerofin. This is designed for pressures from 25 to 350 lb. gage.

BULLETIN NO. 10 issued by the Ellison Draft Gage Co., 214 West Kinzie St., Chicago, describes its new pointer draft gage with straight line movement. This has four illuminated scales showing the draft at four points in the gas passage, selected according to the conditions of the plant. It is also made up in panel form with any number of scales desired and can be arranged with a color code to designate the various points for which draft is registered.

TYCOS ROCHESTER for January, 1928, published by Taylor Instrument Cos., Rochester, N. Y., among other interesting articles, contains a discussion by C. Moran on Forests and Flood Control. Fundy's Famous Tides also are described and an article on Birds That Follow the Sun contains some interesting pictures of duck and other wild game.

SULLIVAN MACHINERY CO., 122 S. Michigan Ave., Chicago, Ill., has just issued several bulletins discussing its products. Bulletin 124 entitled "Speed Up with Air" shows applications of portable air compressors and compressed air tools. Bulletin 83-1 describes WG-6 single-stage, belt-driven horizontal Sullivan compressors in capacities from 68 to 500 c.f.m. Bulletin 76-G discusses the 6½-hp. portable motor-driven hoists. Bulletin 83-H describes Sullivan vertical air compressors, two and four-cylinder types, in capacities of 120 to 240 c.f.m. for small power plants and miscellaneous industrial requirements.

GOULDS PUMPS, INC., Seneca Falls, N. Y., is issuing a folder describing a portable engine-driven pumping unit designed for fire or general service. This is made in capacity of 250 g.p.m., at 100 lb. pressure and 1100 r.p.m.

ROTARY CAR DUMPERS are described in Bulletin No. 103, issued by Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

THE LANHAM MANOGRAPH, a flow meter for water and steam, is described in a recent bulletin issued by Paul Lanham, Lanham, Md.

STARTING AND OPERATING characteristics of the Lincoln "Switch-Start" Motor are discussed in a recent folder by the Lincoln Electric Co., Cleveland, Ohio.

DE LAVAL single stage and multistage centrifugal pumps for all services are described and illustrated in Catalog B, a 72-page bulletin just issued by DeLaval Steam Turbine Co., Trenton, N. J.

STEPHENS-ADAMSON MFG. CO., Aurora, Ill., has issued a four-page illustrated folder describing the new JFS variable speed transmission.

CELITE PRODUCTS CO., 1320 S. Hope St., Los Angeles, Calif., has issued bulletin No. 336, entitled "Designing Concrete for Workability as Well as Strength." This deals with the use of Celite in concrete.

FILTRATORS for keeping boilers permanently clean, as manufactured by Filtrators Co., 96 Liberty St., New York, N. Y., are described in a folder recently received, which shows the construction of the device, the method of attachment, and explains the principle and operation of the device.

ALLEN-BRADLEY CO., 286 Greenfield Ave., Milwaukee, Wis., has issued several bulletins and leaflets to be inserted in its loose leaf catalog, describing across-the-line starting switches for d.c. motors and starting devices for squirrel cage and slip ring motors. Alternating current reversing switches are described and across-the-line starting switches for a.c. motors of various types.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 W. 39th St., New York, N. Y., in an 8-page bulletin announces and describes the new Engineering Weekly Card Index Service. This is designed to make available the facilities of the United Engineering Societies Library, said to be the largest strictly technical library in the world, containing over 1700 technical publications from 37 countries and in 17 languages. The service makes available in card index form ready for filing all the data on technical articles published by the Engineering Index, which is carried on by a special organization within the A. S. M. E. The service was inaugurated as of January 3, 1928, after a year of preparation. Bulletin contains complete data regarding prices for the various classes of service and a list of publications reviewed by the Service.

Power Plant Construction News

Ariz., Yuma—The Arizona Edison Co. is considering extensions and improvements in plant and system, including installation of additional equipment and transmission lines, reported to cost about $90,000.

Calif., Sacramento—The Western Oxygen Co., 2421 East Fifty-eighth Street, Los Angeles, Calif., plans the installation of power equipment at its proposed local industrial oxygen plant, entire project to cost close to $100,000.

Conn., Montville—The Robert Gair Co., 420 Lexington Avenue, New York, has approved plans for a one-story boiler plant at its local paper mill, reported to cost about $50,000.

Ga., Columbus—The Chattahoochie Sand & Gravel Co., Columbus, plans the installation of power equipment in connection with a proposed sand and gravel plant on the Chattahoochie River, estimated to cost more than $150,000 with machinery.

Ill., Harrisburg—The Firebrand Fuel Co., Norris City, near Harrisburg, is planning the rebuilding of the power plant at its local coal mines, comprising boiler and engine house, destroyed by fire March 7, with loss estimated at close to $100,000.

Ill., Ottawa—The National Plate Glass Co., General Motors Building, Detroit, Mich., plans the installation of power equipment in connection with a new addition to its plant reported to cost in excess of $200,000.

Ill., West Pullman—The Columbia Mills, Inc., 225 Fifth Avenue, New York, will install power equipment in a proposed one, two and three-story addition to its local textile mill, reported to cost in excess of $250,000. Lockwood, Greene & Co., 400 North Michigan Avenue, Chicago, Ill., are architects and engineers.

Ind., Brazil—The United Brick Co., care of J. E. Hendrix, Veedersburg, Ind., (recently organized by Mr. Hendrix and associates) plans the construction of a boiler house at its proposed local brick plant; entire project will cost in excess of $60,000.

Ind., Shelbyville—The Fame Canning Co., 58 East Washington Street, Chicago, Ill., plans the installation of power equipment in connection with proposed rebuilding of its local plant, recently destroyed by fire, with loss approximately $200,000.

Iowa, Burlington—The Iowa Soap Co., 816 Valley Street, will install power equipment in a proposed three-story addition to its local plant, estimated to cost about $100,000; bids will be asked on general contract early in April. The Federal Engineering Co., Central Office Building, Davenport, Iowa, is engineer.

Kans., Meade—The Silica Mines Co., Meade, plans the installation of power equipment in a proposed new plant unit estimated to cost about $65,000. M. T. Garlow is head.

Ky., Louisville—The Kurfees Paint Co., 201 East Market Street, will install power equipment in a new factory addition to cost about $85,000, for which plans have been filed.

La., Abbeville—The Dixie Creamery, Inc., 2419 Southern Avenue, Shreveport, La., plans the installation of power equipment in its proposed local plant, entire project to cost close to $100,000.

Mass., Alliston (Boston)—The Albany Carpet Cleaning Co., 18 Penniman Road, has filed plans for an addition to its boiler plant, in connection with factory expansion, estimated to cost in excess of $40,000, with equipment.

Mass., Boston—The Board of Trustees, Boston City Hospital, has plans for extensions and improvements in power house at the institution, Albany Street, to cost about $200,000, with equipment. James H. Ritchie & Associates, 100 Arlington Street, are architects.

Md., Cumberland—The Kelly-Springfield Tire Co. will install electric power equipment in a proposed new addition to its plant, estimated to cost about $100,000.

Mich., Battle Creek—The Ralston Purina Mills, Inc., will install power equipment in connection with proposed rebuilding of its local cereal mill, destroyed by fire March 4, with loss estimated in excess of $200,000, including machinery.

Mo., Kansas City—The United States Cold Storage Co., Third and Locust Streets, is considering the erection of a new unit at its ice-manufacturing and cold storage plant, including improvements in present ice-making division. Entire project will cost more than $2,000,000.

Mont., Polson—Walter H. Wheeler, 1110 Metropolitan Life Building, Minneapolis, Minn., engineer, has plans under way for a steam-operated electric power plant on local site, for a company whose name is temporarily withheld, reported to cost in excess of $45,000, with equipment.

N. C., Greensboro—The Proximity Mfg. Co. plans the installation of power equipment in a proposed addition to its local textile mill, to be used for weaving service, reported to cost about $125,000.

N. Y., Binghamton—The Binghamton Brick Co. is said to be planning the installation of a boiler house in connection with proposed rebuilding of its plant, destroyed by fire March 3, with total loss approximating $200,000.

N. Y., Buffalo—The duPont Cellophane Co., River Road, plans the installation of power equipment in a proposed one-story addition to its glazed paper mill, estimated to cost in excess of $200,000.

Okla., Ponca City—The Empire Refineries, Inc., Tulsa, Okla., will install power equipment in a proposed local plant for manufacture of industrial alcohol, entire project to cost approximately $300,000.

Ore., Oregon City—The Hawley Pulp & Paper Co. is considering the construction of a new steam power plant at its local mill, to be equipped with high pressure boiler units, stokers and other modern equipment, replacing a present such station. Work will be carried out in connection with an expansion and improvement program to cost close to $2,000,000, over a period of months. Willard P. Hawley is president.

Pa., Emaus—Zollinger & Schroth, Inc. plan the installation of power equipment in a one-story addition to textile mill on Furnace Street, estimated to cost close to $100,000. Lockwood Greene & Co., 100 East Forty-second Street, New York, are architects and engineers.

Pa., Wyalusing—The Dairymen's League, Wyalusing, plans the rebuilding of the portion of ice-manufacturing plant and boiler house at local powdered milk plant, destroyed by fire, March 6 with loss of about $25,000.

Vt., St. Johnsbury—The Jackson-Butler Corporation plans the installation of power equipment in connection with rebuilding of its woodworking mills recently destroyed by fire with loss reported at $75,000, including machinery.

W. Va., Kenova—The Tri-State Refining Co. plans the installation of power equipment in connection with a new addition to its oil plant, estimated to cost close to $200,000.

Wash., Bellingham—The San Juan Pulp Mfg. Co. plans the installation of power equipment in a proposed new addition to its mill estimated to cost close to $100,000. Ossian Anderson is president.

Wis., Kenosha—St. Catherine's Hospital, Milwaukee Avenue, has plans nearing completion, for a new power house and service building at the institution, with installation of two 150-hp. boilers and accessory equipment. Schmidt, Garden & Erikson, 104 South Michigan Avenue, Chicago, Ill., are architects.

Wis., Loyal—The Lakeshire Cheese Co. is planning the installation of a boiler plant in its proposed local cheese factory and milk condensory. Entire project will cost about $100,000 with machinery. G. A. Krasin, Marshfield, Wis., is architect.

Wyo., Powell—The Great Western Sugar Co., Sugar Building, Denver, Colo., is reported planning the construction of a beet sugar mill in this vicinity, to include boiler plant and other power equipment. Entire project will cost more than $350,000.